FEB 27 1931

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INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

(Reg. U. S. Pat. Off.)

Devoted to Measurement and Control Problems

Vol. 4. No. 2 Pittsburgh, Pa. February, 1931

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New Aircraft Indicating Instruments
Astronomical Observer's Platform
Automatic Controls for Adjusting Rolls in Steel Mills
New Damping U-Tube
Aggregate Auto Gage
Bending Machine for Static and Repeated Reversed Loads
New Recording Balloon Theodolite
Automatic Excess Temperature Cutout
Precision Threading Lathe
New Flat Plug and Shoulder Snap Gages

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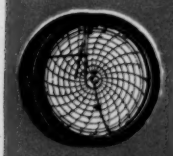
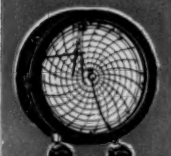
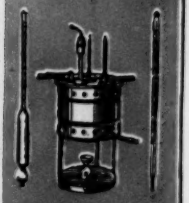
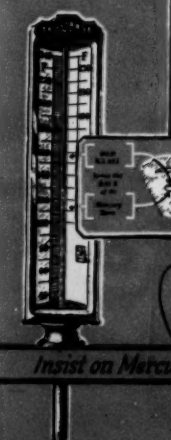
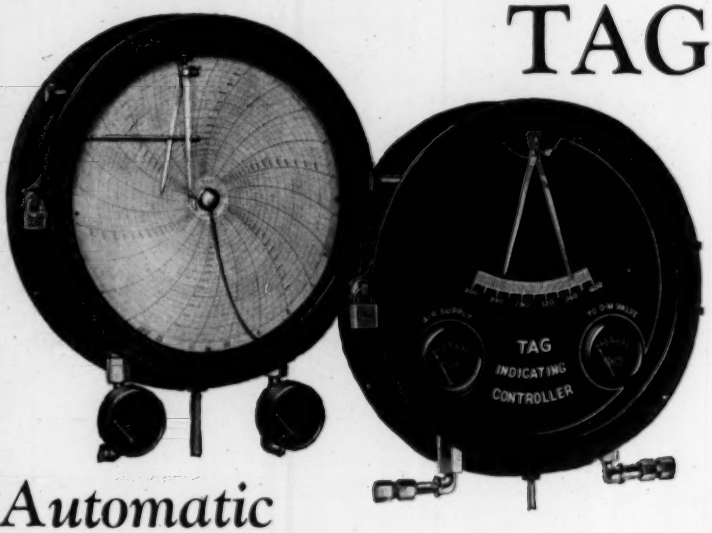








TAG



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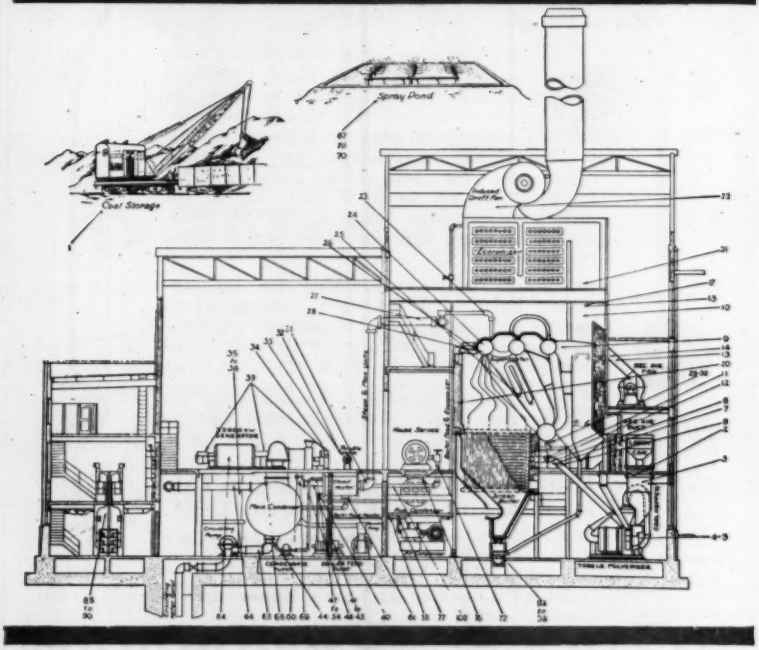

This diagram illustrates the instrument applications discussed in this book. The numbered paragraphs in the text describe the respective applications.

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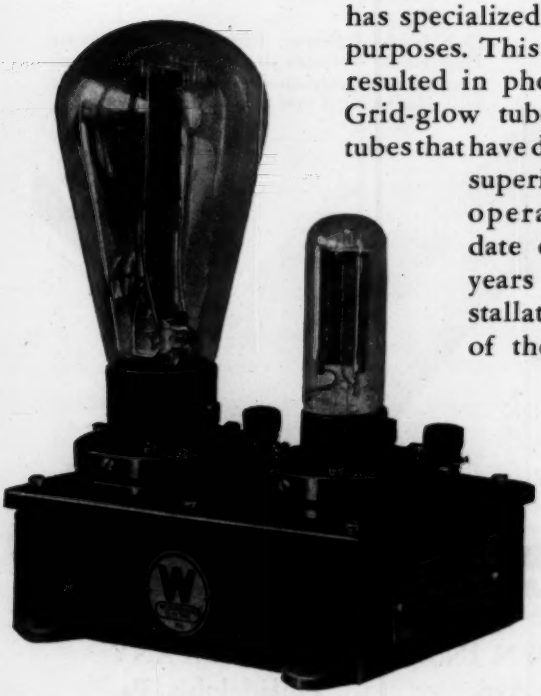

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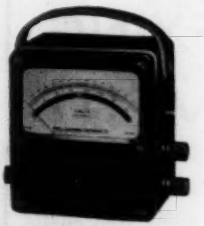

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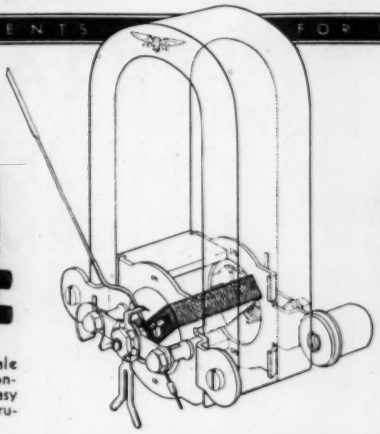

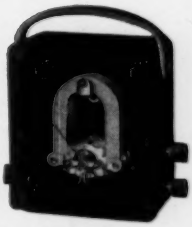

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The high accuracy and permanent calibration of Jewell Master D. C. Instruments are the result of many detailed improvements—the sum total of which represents a notable evolution in meter design.

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Pattern 174—VoltAmp Wattmeter
Pattern 175—PolyphaseWattmeter
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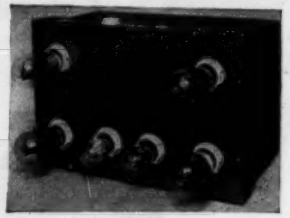
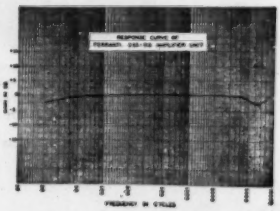


250 D-3
Amplifier Unit



Curve of 250 D-3
Amplifier

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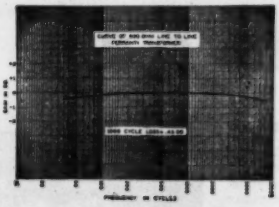

Curve of 600 ohm
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Ferranti amplifying equipment and special precision impedance matching transformers can be supplied for a wide variety of uses in laboratories, and in the educational and commercial distribution of voice and music.

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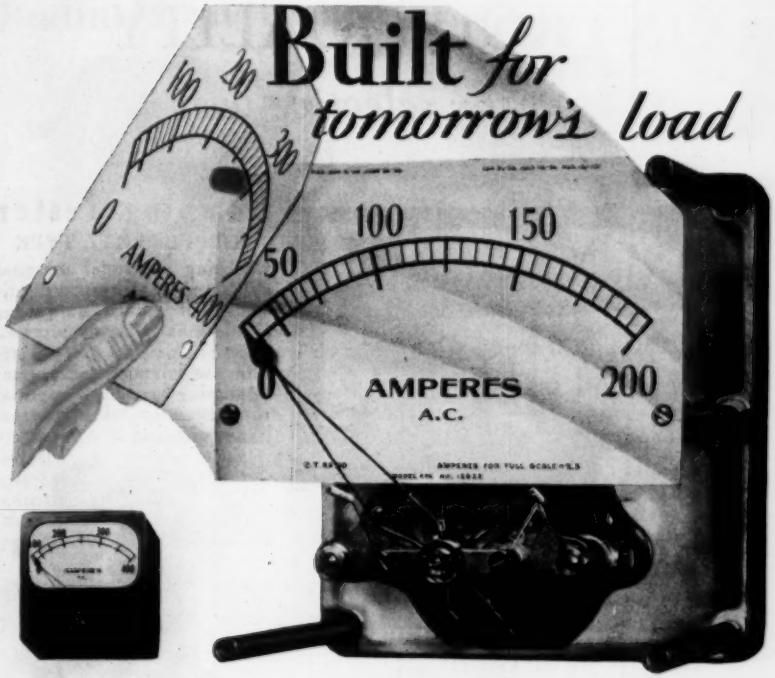

ANOTHER interesting problem that has confronted design engineers of central and sub stations has been solved.

Through a novel addition to the popular Weston rectangular switchboard line these instruments can now be arranged for indicating present day as well as Tomorrow's maximum power loads.

This innovation provides definite economies in equipment cost because it eliminates replacing meters and associated transformers as power loads increase—*both can now be installed initially for the ultimate load.*

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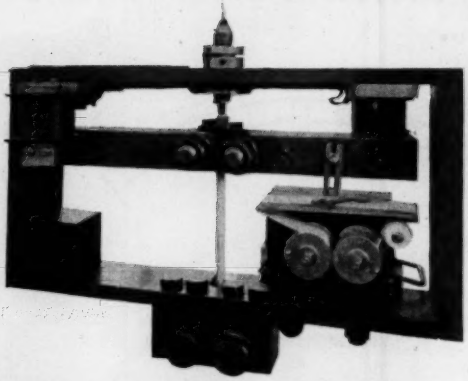

Damping Tester

FOEPPL-PERTZ TYPE

Choosing of proper material subjected to vibratory conditions will reduce dangerous oscillations of highly stressed parts. This machine determines which materials possess "damping capacity" essential to prevention of high resonance stresses.

Bending Fatigue Machine

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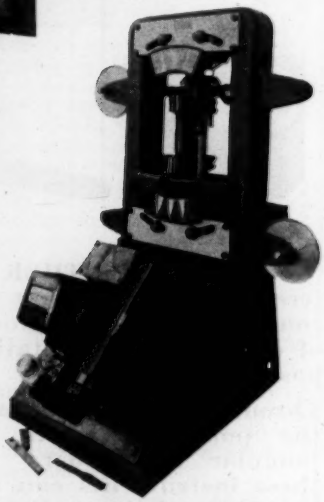
Make your own endurance vibratory tests on cheap specimens. First machine with varying bending stress of equal magnitude throughout entire gauge length. Specially suited for welded flat specimens. Easy to operate.



Brinell Hardness Tester

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This lightweight machine gives direct reading of indentation depth, in addition to Brinell readings. Loadings up to 11,000 lbs. transverse and compression.

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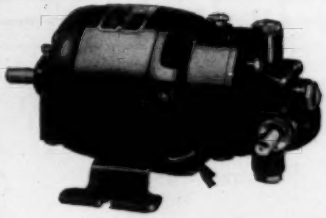
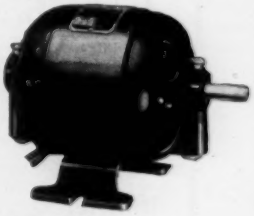
Bodine Fractional Horsepower Motors





Continuous Service Induction Motors

Single Phase-Shaded Pole

There are hundreds of devices in the laboratory and in industry which require a small reliable constant speed motor. The Bodine Types CA-2 and CAR-2 Motors are continuous service single phase induction motors without commutators, brushes, centrifugal cutouts, or rotor windings. They are self-starting and are rated from 1/80 to 1/1300 H.P. at 1025, 1500 or 3275 R.P.M.

When equipped with built-in speed reducers, slow motion shaft speeds available are: 176, 88, 43, 21, 10, 5, 2½, or 1.3 R.P.M. Where slow motion and small power are required, these Bodine Motors are ideal power units. Send for bulletin No. 1010 describing these motors.

Other Bodine Motors for Laboratory and Industrial Service

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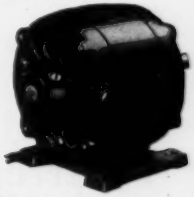
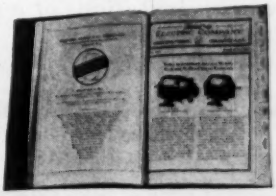
Type V Series Universal Motor. Rated at 1/100 H.P. at 4000 R.P.M. For motion picture projectors, automatic control devices, etc. Operates on either alternating or direct current.



Type N-5 Constant Speed A.C. and D.C. Motors. Rated at 1/20 and 1/12 H.P. at 1125 R.P.M., and 1/10 and 1/8 H.P. at 1725 R.P.M. Furnished with wool-packed bearings.

Leading instrument manufacturers have adopted Bodine standard and special motors for their equipment.



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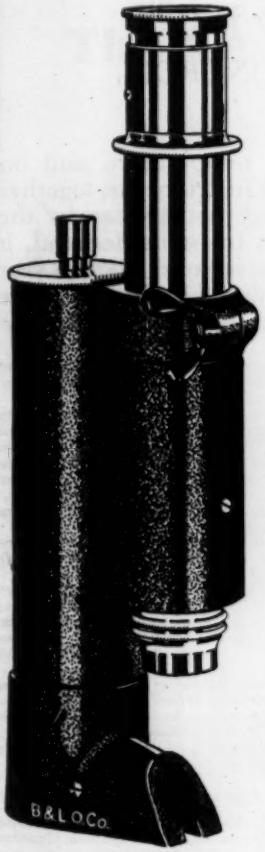

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By M. F. Béhar

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Our engineers think most higaly of it. *C. P. Dewslow, National Meter Co.*

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I have been following with considerable interest what you have published in *Instruments*. It has been excellently handled. *R. L. Goetzenberger, Minneapolis-Honeywell.*

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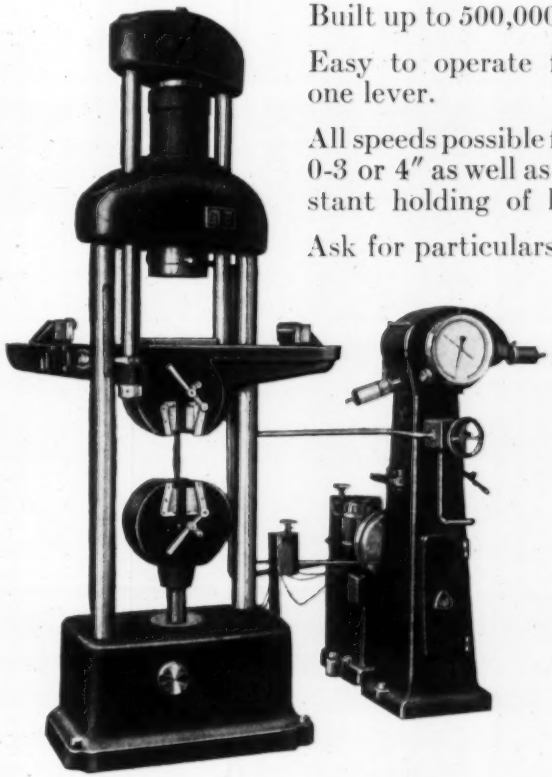

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Richard Rimbach, Managing Editor **M. F. Behar**, Engineering Editor

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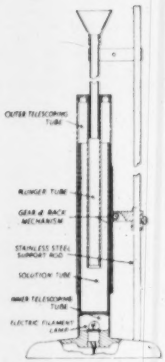

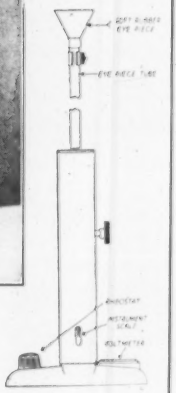

Above: photograph showing method of operation. Left and right: descriptive illustration of turbidimeter showing construction and mechanical details.

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EDITORIAL COMMENT

What Manufacturers Should Know About Our Two Instrument Handbooks

In spite of letters which the managing editor has written to every instrument company in the last fourteen months, in spite of definite statements made on this editorial page, certain manufacturers complain of being "overlooked" by the authors of the two handbooks appearing serially in INSTRUMENTS—in that both authors "seem to think of us only at the last minute."

The complaints refer to the fact that both Mr. Béhar and Mr. Schroder usually request photographs and engravings for their *next* installments. We are told that this implies many months of indifference and a last-minute gesture of mere tolerance.

Such an implication is unjust.

A last-minute request by either author indicates recognition of merit. Let us explain: And here we make a statement not only to manufacturers but

To Our Readers

The Handbook of Industrial Instruments and the Handbook of Laboratory Instruments are designed to supply *up-to-date* information. The engineering editor of INSTRUMENTS and the director of technical service of the Fisher Scientific Co. are both experienced instrument men who for years have witnessed (and taken part in) the remarkable development of modern instruments. They both know that alert manufacturers are constantly bringing out improved products. They therefore deliberately wait, in order that each chapter should represent the "state of the art" at the time of printing.

We are convinced that this is a wise policy. We know that it is approved by our readers. We believe that it will be appreciated by those who will purchase the Handbooks when we bring them out in book form.

What is more, six or seven striking instances have already furnished conclusive proof of the wisdom of this policy. We may mention some.

Important First Announcements

When Mr. Béhar's chapter on temperature recorders was written, and until only a few days before it had to be set in type, there were in all the world only two industrial recording pyrometers of the potentiometer type. At the "last minute" a third instrument firm informed him *by telegram* that it had brought out such an instrument. Photographs, diagrams and technical data followed by mail. Working two successive nights our engineering editor was able to re-arrange and expand his chapter and the result was the first illustrated description of this industrial instrument to appear anywhere.

Similarly, although the chapter on humidity instruments had been written in 1929, it was purposely kept from our printers, and just before its appearance Mr. Béhar made a final survey of the field. Again there was an interchange of telegrams with a manufacturer and he received a set of photographs of a new humidity controller directly from the retouching studio before these photographs were sent to the manufacturer's own advertising men.

It was the same story with a new control pyrometer embodying several interesting features. It was the same story with two new hygrometric indicators. And history will repeat itself. Thanks to this policy the future instalments of both Handbooks will continue to deserve the commendations of all our readers—those interested in industrial instruments and controls, and those interested in laboratory instruments and apparatus.

Gratifying Cooperation

Both Mr. Béhar and Mr. Schroder, with whom we discussed these matters, urged us to remember to express thanks for the assistance they are receiving from manufacturers, and also from scientific and engineering bodies, institutions such as the Bureau of Standards, and various individual research specialists. It is a pleasure to do so—not so much on their behalf as on behalf of the thousands of readers of INSTRUMENTS who receive the full benefits of this whole-hearted collaboration.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

PHOTOELECTRIC CELLS. *By Norman Robert Campbell & Dorothy Ritchie.* Isaac Pitman & Sons, New York, second edition, 1930. Cloth, 5½ x 8 inches, 217 pages. Price $4.50.

The text is divided into 3 parts as follows:

I Theory of Photoelectric Cells
II Use of Photoelectric Cells
III Application of Photoelectric Cells.

Although the authors in their preface to the first edition state their intention "to regard the photoelectric cell, not as an illustration of important laws and theories, but as a laboratory or workshop tool," this book should not be considered an engineering manual but as a rather complete and practical text for the research or engineering physicist. Extensive mathematical treatment does not encumber the wealth of scientific information offered, although for the sake of completeness, a considerable part of the book is given to the description of fundamental phenomena in which only the specialist in photoelectric cells will find interest.

Part I briefly reviews the theory of operation, fundamental laws of photoelectricity, and the mechanical, electrical, chemical, and optical (particularly the spectral) characteristics of vacuum and gas-filled cells. The properties of various photoelectrically sensitive materials are discussed in some detail leading up to the most modern types of thin film, composite surface cells. In introducing their subject, the authors definitely differentiate between the photoelectric effect in which "light produces an emission of electrons" and other light sensitive phenomenon, such as the photoconductive (selenium cell). No attention is given to any but the former subject.

Part II discusses the general circuit arrangements in which photoelectric cells may be used for the measurement of light intensity or color. Electrostatic methods are thoroughly described but are of doubtful value for work other than laboratory research. Method of valve amplification of photoelectric currents are given with particular reference to the factors which determine sensitivity, stability, and frequency response. Special methods of amplification using glow tubes are briefly described.

In Part III consideration is given to the practical aspects of lamps, stellar photometry, spectro-photometry, measurement of illumination, and of ultra-violet light. The final chapters discuss color matching and the measurements of light absorption.

The authors are members of the Research Staff of the General Electric Company, Ltd., Wembley, England. Throughout the book a considerable amount of material resulting from the original researches of the authors is included. To be complete, rather too few references are made to the recent work of others in the field of photoelectric cells, particularly those in the United States.

This second edition is essentially a reprint of the first, but does contain an appendix in which brief notes on some of the more recent developments of an important practical nature are mentioned. The book has a good index.

A. J. McMaster

Centralized Control Improved Production

A. J. A. Peterson*

CENTRALIZED control means more than the grouping together of many instruments and control switches into a limited amount of space. It also means the ability of one man to control or administer the operation of a large number of industrial machines in the same sense that a load dispatcher administers the generation and distribution of power in a central station system.

Fig. 1

A large chemical plant in Niagara Falls applied to its problem of machine and load control the same principles used in the central station industry. In this plant, the operator must control and supervise 10 to 14 manufacturing units, all forming heavy electrical loads, and must supervise the incoming supply as well. He must observe the performance of each of his units, and manipulate the individual controls in accordance with his observation of the various instruments. Adequate and satisfactory control at the individual units is out of the question. The concentration in a single control room seems to be the proper answer. However, the conventional desk or panel board would still be too cumbersome for good operation, so some other form of switchboard was sought to facilitate as far as possible the continuous work of the operator.

Fig. 1 shows the switchboards developed through the collaboration of the engineers of the chemical company and those of the Westinghouse

*Switchboard Engineering Department, Westinghouse Electric & Manufacturing Company

Electric & Manufacturing Company, as the solution of their particular problem. In this arrangement, the operator is seated directly in front of a 7-section circular board. On these panels are located the various indicating instruments required for close observation and the switches for controlling the oil circuit breakers and regulating the load. The outer circle of panels mounts the protective relays, graphic instruments, and additional indicating instruments on which such close observation is not necessary.

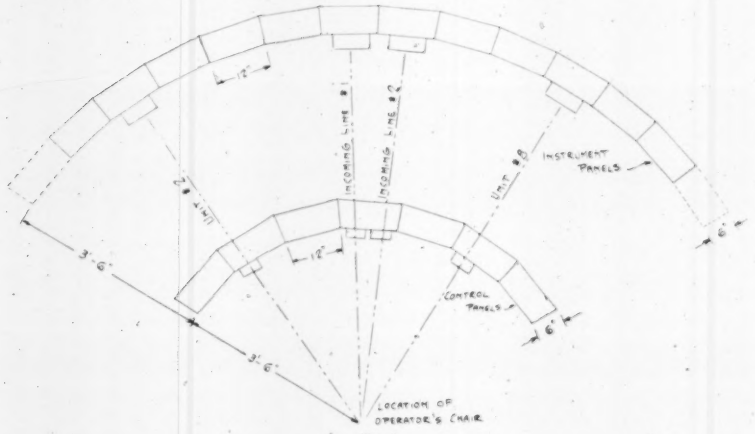

Fig. 2

The inner switchboard is made up of 7 panels, each 41″ high, 12″ wide, and 6″ deep, all mounted on a 3″ high base. The center panel controls two incoming line circuits, and each of the other six panels controls two manufacturing units. These were designed as double unit panels in order to increase the space factor above that obtainable with very narrow panels. The outer switchboard is made up of 15 panels, each 90″ high, 12″ wide, and 6″ deep. Each of these is for one unit, corresponding to the half of the inner panel directly in front of it. Standard Westinghouse steel panel construction is used throughout, in order to obtain the best possible effects of appearance, light weight, and complete enclosure of vertical wiring. The 6″ depth of panels results in a rigid self-supporting switchboard without external braces. The inner panels are provided with a smooth top and complete cover on the rear, thus completely enclosing all equipment normally mounted in the back of a switchboard panel. By this means, the inner switchboard forms a rail for the passage way directly in front of the outer board. The front panels are mounted on a base made of two channels standing on edge, thus facilitating the entrance of conduits into this switchboard.

The arrangement of the assembly is such that the front faces of the inner switchboard are on a 42″ radius, while the front faces of the outer switchboard are on an 84″ radius.

As shown in Fig. 2, the instruments on the outer panels are in line with the corresponding instruments on the inner circle, this line being a radius on which the two switchboards are erected. Thus, the operator, at the center of these two circles, has under straight line observation the instruments and controls on the inner panels and the instruments on the outer panels, all corresponding to one unit.

In addition, the height of the inner switchboard has been chosen so that the operator may observe the instruments at the top of the outer switchboard, and at the same time have within his vision while seated, the scales and charts on the graphic instruments located near the bottom part of the outer panels. This is illustrated in Fig. 1.

Thus when the operator chooses to make adjustments on a certain unit, he turns to that position. He is able to look directly at the instruments in front of him, handle the control switches, and also look directly over the inner switchboard panels on the same radius line to the corresponding instruments on the outer switchboard. In addition, he can glance downward over the rear edge of the inner switchboard and observe the position of the pointer on the graphic ammeter, and the record of the performance for the period immediately preceding.

Undoubtedly, the future will bring similar problems, and it is expected that the industrial and manufacturing engineers will be able to develop the tools necessary for improved production.

To keep pace with its steadily increasing business, the Meriam Co., 1955 West 112th St., Cleveland, Ohio, has now completed a 50% extension to its plant. The building is of the Truscon standardized type, and will house the welding department and storage; and will allow the entire space in the main building to be devoted to the manufacture and testing of the manometers, flow meters, draft gages and shock absorbers. This is the third increase in manufacturing space which the Meriam Co. has found necessary during the past 4 years.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

PHOTOELECTRIC CELLS & THEIR APPLICATIONS. A Discussion at a Joint Meeting of the Physical and Optical Societies (England), June 4 & 5, 1930. Edited by *John S. Anderson*. Published by the Physical and Optical Socities, London. Paper, 7 x 10 inches, 236 pages. Price 12s. 6d.

This book is a compilation of 31 technical papers followed by a report of the general discussion thereof presented in June 1930, at a joint meeting of the English Physical and Optical Socities. The papers were read by the authors who comprise a considerable proportion of the principal investigators of various countries in the field of light sensitive cells and their applications.

The papers cover a large variety of inter-related divisions of this field including the history, development, manufacture, standardization, and application of both photoelectric (electron emitting types) and photo-conductive (selenium, etc.) types of light sensitive cells. Many, although not all, of the modern types of photoelectric cells are discussed, the particular merits of each being proclaimed by their respective investigators.

The merits of both selenium and alkali metal cells in the reproduction of sound from film with respect to their relative output and frequency response are given. Although selenium cells have an admittedly large time-lag, it is claimed that compensation may be readily provided since the response—frequency curve is nearly a straight line. Various electrostatic and thermionic valve methods of measuring photoelectric currents are described. Applications of photoelectric cells to biological work, phototherapy, measurement of daylight, and micro-photometry are a few of the many practical uses of the light sensitive tool which are reported.

A rather complete résumé of the use of the photoelectric cell in spectro-photometry is given. Several instruments for this work are described and their advantages and limitations are discussed.

In a treatise prepared by such a large number of authors, there is, of course, a lack of both unity and coherence. The papers are of a strictly scientific nature and will appeal more to the physicist than to the engineer. However, to one who has some working knowledge of the subject, this book will provide many hours of delightful reading and study. It is probably the most authentic and up-to-date single source of specific information on photoelectric cells today.

A. J. McMaster

The Measurements of Air Flow

By

E. Ower, B. Sc. (Lond.), Hons. I., A.C.G.I.

Bramwell Medallist; Member of the Institution of Heating and Ventilating Engineers; Assistant in the Aerodynamics Department, National Physical Laboratory.

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II. General Principles of the Pressure Tube Anemometer.
III. Design of Pitot and Static Tubes.
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VI. The Plate Orifice, Venturi Tube, and Shaped Nozzle.
VII. The Vane Anemometer.
VIII. Miscellaneous Methods of Flow Measurement Depending on Pressure Observations.
IV. Manometers.
X. Methods of Flow Measurement Based upon the Rates of Cooling of Hot Bodies.

200 pages—73 illustrations

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THE HANDBOOK OF INDUSTRIAL INSTRUMENTS

CHAPTER XI

Pressure Measuring Instruments

M. F. Béhar*

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Notes

(1) The design of the present chapter is to describe pressure measuring instruments, without going into their uses. In most cases the measurement of pressure calls for the application of very simple principles. Unlike a thermocouple—which to the eye is nothing but a pair of wires, yet requires careful study with respect to its ability to measure temperatures—a pressure gage is in principle understandable "at a glance" even if it embodies elaborate construction refinements. There is then little need for wordy descriptions and it is believed that for most industrial types, illustrations—more than 100 of them—can serve the purpose by affording the "glances." Exceptions are noted below.

(2) To the user of pressure measuring instruments, and to the student of their uses, it must be said however that even the most correctly designed and honestly built manometer or gage will give fictitious indications when improperly installed or incorrectly employed. This is true of all instruments, but many sources of error, *between* the place where pressure is to be measured and the pressure instrument, are often overlooked, and therefore the preceding chapter should be referred to. Otherwise the present chapter might give rise to erroneous first impressions obtained from appearances and brief descriptions.

(3) The great majority of all pressure gages—even the best ones—require periodical calibration or standardization. Therefore, Section 1 on Plant Standards and Section 2 on calibration are purposely placed ahead of the descriptions of manometers and gages.

(4) In connection with elastic-member gages—such types as Bourdon tube, aneroid box, diaphragm, membrane-and-spring, bellows, helical tube, etc.—pictures and brief descriptions are not quite adequate because of the present confusion with regard to "fatigue," hysteresis, endurance tests, and other subjects related to such instruments. The author therefore includes summaries of recent authoritative reports and discussions on properties of elastic materials, sources of error, etc. These apply to *all instruments embodying elastic members of any form*. Busy readers and practical instrument maintenance men may—and no doubt will—skip these discussions and they may safely put their trust in whatever instruments are supplied to them by reputable manufacturers. These discussions are designed for engineers and other men that demand more than sketchy descriptions. Hence the references.

*Engineering Editor.

TABLE XVII.—ACCURACY & SENSITIVITY OF USUAL COMMERCIAL PRESSURE INSTRUMENTS

(Prepared for this Handbook by a prominent Central States instrument company)

TYPES OF INSTRUMENTS	ACCURACY: Limit of error expressed as either (Over entire range) One part in—	or (For a reading) Percent	ULTIMATE SENSITIVITY: Least pressure change to cause effective motion of indicating element (Short range instruments)	When range is	(Usual range instruments)	When range is
Liquid Column			Inches water		Inches water	
Glass U-tubes—One liquid	1,000	1	0.02	3 in.	0.05	60 in.
Glass U-tubes—Two-liquid multiplying	2,000	1/2	0.01	3 in.	0.02	25 in.
Float types as in flowmeters	500	1	0.002	0.2 in.	0.13	13 in.
Single tube and well—Vertical	1,000	1	0.02	0 to 6 in.	0.02	0 to 100 in.
Single tube and well—Inclined	1,000	1	0.005	0 to 0.5 in.	0.01	0 to 3 in.
Precision forms (mostly **non**-commercial)	40,000	1/100	0.0001	0 to 1 in.	0.0005	0 to 4 in.
Weight-loaded			lb./sq. in.	lb./sq. in.	lb./sq. in.	lb./sq. in.
Piston—Dead weight, scale, etc	2,000	1/2	0.05	0 to 100	1.0	0 to 5000
			Inches water	Inches water	Inches water	Inches water
Inverted bell, etc	1,000	1	0.005	0 to 0.5	0.05	0 to 25
Ring and tilting	1,000	2	0.01	0 to 0.1	0.1	0 to 5
Elastic Deformation			lb./sq. in.	lb./sq. in.	lb./sq. in.	lb./sq. in.
Bourdon tube	500	2	0.1	1 to 5	10	5000
Helical tube	500	2	0.1	0 to 5	5	500
			Inches water	Inches water	Inches water	Inches water
Metal diaphragm	1,000	2	0.01	0 to 2	0.1	0 to 10
Bellows	1,000	1	0.01	0 to 1	0.05	0 to 100
Spring-loaded membrane	500	2	0.002	0 to 0.2	0.5	0 to 50
			lb./sq. in.	lb./sq. in.	lb./sq. in.	lb./sq. in.
Spring-loaded piston	500	3	0.2	0 to 10 lbs.	0.5	0 to 500

NOTES—(1) The noted Chief Engineer who filled in the values in the above table had been asked to keep in mind the usual commercial pressure measuring instruments; and he did. For example, in the case of "Single tube and well—vertical," he did not fill in the accuracy and sensitivity of a vernier-equipped barometric open-cistern gage. (2) There is no discrepancy between the values under the two ways of expressing accuracy; an instrument consistently accurate to one-thousandth of its range may be accurate to 0.1 per cent when indicating a pressure in its upper region, but it may show an error of more than 2 per cent when used to measure a low pressure.—M. F. B.

(5) Some non-industrial instruments are included. This is a departure from the general plan of the Handbook but "the scientific instrument of today will be an industrial instrument tomorrow," and the author has selected only those the "industrialization" of which appears to be not only urgent but iminent.

(6) As an example we may cite the "null method." A few years ago most engineers would have declared this method (that of the potentiometer in measurement of emf) impossible of application for pressure measurement. Today it is successfully applied in liquid column instruments such as the Ernsberger and Whalen and in an elastic member instrument—the Paulin barometer. And the latter has already reached the stage of quantity production as a commercial article.

(7) *Tables of Characteristics*—After trying for several months to compile *one* complete table of *all* important characteristics of *all* types of pressure measuring instruments, one must conclude that the size of such a table would destroy its practical reference value: four times the area of this page would be required to present it in small type. One reason is that the characteristics vary with the application; another is that even an individual liquid-column instrument will have different characteristics when filled with different liquids or different *pairs* of liquids. It was therefore decided to print *partial* but specific and *easily consulted* tables. The principal characteristic is *Range of Applicability* and this has been given graphically in the chart which forms part of Table IX in Chapter X. Other characteristics are now given in Tables XVII, XVIII and XIX, each of which has been compiled by one company or research specialist and gives specific information.

(8) Neither in illustrations nor in comments has exhaustiveness been striven for. There are on the market so many different models of almost every type that an exhaustive pictorial catalog of small illustrations and brief descriptions would fill a book. Therefore a selection had to be made, both in pictures and text—and the underlying aim was suggestiveness, rather than tedious repetition of what every engineer knows. Several familiar models are not shown and some excellent makes are not mentioned, but the residuum (three or four times as many practical data as are obtainable in any other one source) needs no apology.

1. Plant Standards *(continued)*

(Ten pages of Section 1 appeared in last month's issue)

(d) Dead Weight Gage Testers *(addendum)*

Another recent development, just reported from England, seems to indicate that the honors must go to some of our British cousins for producing a line of precision testers including one model designed for pressures up to 94,080 lb. per sq. in.—by far the highest pressure for which commercial testers are made. In this model, shown in Fig. 239, a special design of piston and a novel method of carrying the weights are used on the suggestion of the National Physical Laboratory. The N.P.L. also certifies the measurements of the glass-hard special alloy pistons of these testers, which are ground and lapped to within the hundred-thousandth of an inch. Inasmuch as these testers have not as yet received any publicity at all in the U. S., it may not be amiss—since one purpose of this Handbook is to fill gaps—to supply further details:

Every detail has been specially developed to suit the enormous pressure which has to be measured. The body of the screw press and the base of the dead weight gage are forgings of high-tensile alloy steel specially treated to obtain density and toughness. The screw of the press is geared down at a ratio of 2.5 : 1. The hand wheel is 36 in. in diameter over the spokes. The cylinder of the screw press is made of carbon steel, hardened and lapped, and the piston of special alloy steel. The diameter is 12.5 mm. and the stroke 120 mm. The filling pump fitted at the back—see right-hand illustration—is made entirely of forged steel finished bright all over. The valves are spring loaded. By means of the pump initial pressures up to 6 or 7 tons per sq. in. can easily be produced. The oil is drawn by the pump from a container at the back. There is a valve on the right to control the filling and a main shut-off valve on top of the body of the press to hold the pressure in the dead weight portion while the cylinder is refilled, as is required when the capacity of the vessel under test is large. In the ordinary way when a pressure gage with a tube of normal capacity is being tested a

pressure of 42 British tons per sq. in. can be reached comfortably with about three-quarters of the stroke of the press plunger. The base of the dead weight gage is fitted at the left with a release valve to return the oil to the container after the test.

A stout steel pillar is mounted on the base, into the top of which is screwed the cylinder. The cylinder is made of crucible cast steel, hardened and lapped to a high degree of accuracy to fit the piston with the minimum of clearance.

The pistons of this model are claimed to be perfect. One tested and measured at the N.P.L. was found to be accurate to within one hundred thousandth of an inch of the nominal diameter, the nominal diameter being 0.11284 and the certified mean diameter at 62° F. 0.11285.

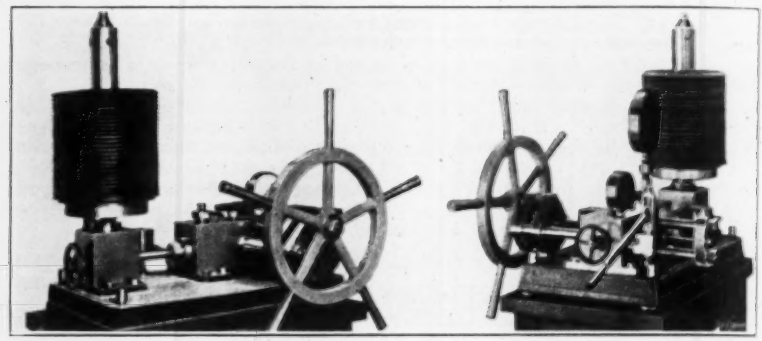


Fig. 239. Dead weight gage tester. (*The Budenberg Gage Company, Ltd.*)

Ten measurements were taken over the cylindrical surface, five along each of two generator lines spaced at 90° to each other, and it was found that the surface was truly cylindrical to within 0.00002 in.

The piston is fitted with a head and ball socket to support the weight carrier. This weight carrier is loaded with a small balance weight to give a round starting figure. The carrier, balance weight and additional annular weights are machined all over and calibrated to within half a grain dead weight.

When the system has been perfectly cleared of air by rotating the piston and weights for a considerable period, the weights, after being set in motion, will revolve for several minutes under the full pressure of 42 tons per sq. in. As the effective left of the piston is only $\frac{1}{16}$ in. and the volume of oil required to float the piston is 1/1600th of a cubic inch—i.e., the volume required to raise it from the position of rest to the level of the working height—the actual leakage of oil is extremely minute even under the full-load pressure of 94,080 lb. per sq. in.

(e) Fluid Pressure Scales *(addendum)*

A Swiss fluid pressure scale, of which a number are in use in the U. S., is shown (somewhat dimly) in Fig. 240. It is a beam balance, the small arm of which tends to press a piston into a cylinder, oil being the medium, as usual. Oil does not enter the gage under test, however, but it acts on the water which fills the upper cylinder, to which the gage is attached. The beam carries three knife-edges. The one at the left bears on the upper crosshead of a stirrup, the lower crosshead of which carries the piston. The cylinder 3 is located between the columns of the stirrup and is rigidly fixed to the main frame. The piston may be rotated during a test by means of crank handle 4. Pressure is built up by turning crank handle 1, which operates the screw-plunger arrangement 2. This fluid pressure scale has a measuring capacity of 50,000 lb. per sq. in. The rider on the long arm of the beam may be positioned in front of a scale graduated from 0 to 50 kg. per sq. cm. On this scale, 1/10 kg. per sq. cm. can be easily estimated. The sensitivity of the apparatus is said to be "so great that for a load of 1000 atmospheres, differences of ½ atm. are still distinctly perceptible."

(f) Pendulum Manometers

While the pendulum principle is splendidly applicable in many measuring instruments, and while it has the great advantage of automatically adapting the "unit sensitivity" to the order of the magnitude, few industrial forms of pendulum pressure or draft gages can be utilized as Plant Standards. Most forms are not sufficiently "primary." The only pendulum gage which appears to be capable of being calibrated by itself as well as suitable for calibrating gages, is the piston gage incorporated in the pendulum dynamometer. As a matter of fact the pendulum dynamometer (Fig. 241) is a combination indicating and recording pressure gage. In itself it is not a gage tester, because it does not embody a pump for building up pressure. As made by a Swiss firm in the form shown in Fig. 241, however, it certainly can be considered a "primary" standard of high accuracy over a number of

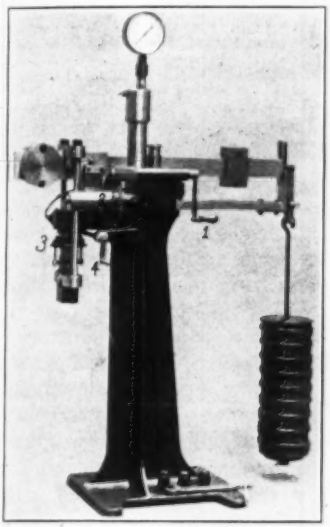


Fig. 240. The Amsler fluid pressure scale (*Herman A. Holz, Amer. repr.*)

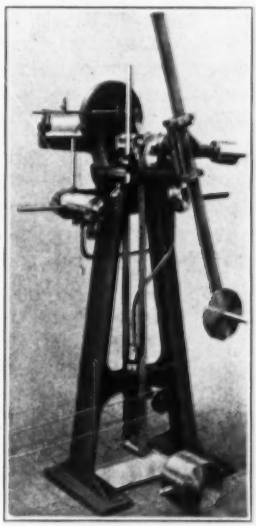


Fig. 241. Amsler pendulum-loaded piston gage. (*Herman A. Holz, Amer. repr.*)

ranges—each range depending on the pendulum length employed and on the weight attached. Fig. 241 shows the weight detached and the pendulum shortened—this disposition being the one for the lowest range. A description of the piston-and-pendulum manometer—as a gage and not as a gage tester—appears in Section 7 below.

Fig. 241 shows the pendulum instrument from the back in order to bring out the disposition of its parts which cannot be seen from the front. This is not a disadvantage, it is claimed, for the operator standing in front can keep his eye on the large dial, and on the gage under test, while manipulating the device.

Objection may be made to the indication of the standard pressure on a dial instead of by means of a set of standardized weights, but this does not seem reasonable: the dial indicates the inclination of the pendulum, which is not the same thing as the deflection of an elastic tube. And it must be remembered that the head in a liquid column Plant Standard must also be read on a graduated scale.

2. Calibration of Elastic-member Gages

The information given in this section, while obtained in large part from sources which the author considers to be the most authoritative, must not be presumed to express the conclusions of any society or to be in any respect "official."

(a) Suitable Testers

Micromanometers are preferably used for calibrating draft and other very low pressure gages; mercury columns for vacuum and most models of low pressure gages; and for all higher pressures the various weight-loaded piston standards are used. The following information applies especially to the use of dead weight testers, by far the more widely used.

Wherever gravitational standards are available, "inspectors' gages" should not be used. Their logical use is out in the field as on oil and gas jobs where convenience or necessity dictates their employment. These test gages should themselves be large or easily-read, sensitive and permanently accurate

(b) Precautions

(1) *Never Reverse the Lost Motion.* There are always two periods, the "ascending" and the "descending." During the first the pressure is increased continuously; during the second it is decreased continuously. In the ascending period, long pauses are allowable with dead weight or scale-beam piston standards because there is no chance for a decrease of pressure while the piston is floating; but with pendulum or liquid column standards the pauses should be just long enough to enter readings, because of the possibility of pressure decreasing momentarily. During the ascending period the pressure should *never be allowed to decrease*, and during the descending period the operator should likewise guard against momentarily increasing the pressure. This is the most important precaution in any calibration procedure. The main purpose of first ascending and then descending is to record (or to plot) the "loop" of the gage, and if pressure is reversed at any time a meaningless loop results, principally by reason of the fact that the hand or pen-arm may be momentarily left to itself, and also because the behavior of the elastic members, under the momentarily uncontrolled method of applying the stress, will be different from their behavior under the controlled or standard method which is the whole idea of a calibration procedure. Therefore, during the ascending period, when pressure is being increased, the piston of a dead weight tester should never pass above mid-position. After a reading is taken at a given pressure, the next weight of a dead weight tester should be added so as to push the piston to the bottom stop, and the pump then operated while the piston is being spun, until it just floats in mid-position while spinning, without passing beyond this point. Similar precautions should be taken with any other type of tester. If the desired pressure is exceeded accidentally by the slightest amount, the pressure should be released and reapplied. With a dead weight tester, the piston will first fall to the bottom and the pressure should again be applied so as to secure floating in mid-position while spinning, without rising above this position.

When maximum pressure is reached, the pump pressure should be increased so as to pass the maximum pressure and then should be decreased and a *second reading taken at maximum pressure.*

The pressure should then be continuously decreased. During this descending period, the piston of a dead weight tester should never pass below mid-position. After a reading is taken at a given pressure, the last weight should be removed so as to bring the piston to the top while keeping the piston from rising too far by the hand, and the pump released while the piston is being spun until it just floats in mid-position (and similarly for any other type of tester). If the desired pressure is accidentally passed by the slightest amount, the pressure should be applied and then released. With a dead weight tester, the piston will first rise to the top while being restrained by the hand, and the pressure should then be released so as to secure floating in mid-position while spinning, without falling below this position.

A good operator can increase pressure during the ascending period and decrease pressure during the descending period, so as never to have to reverse and go back, all without any appreciable effort.

(2) *See that Gage Hand is Properly Fastened* and otherwise cursorily inspect the instrument to be calibrated, to see that it is in condition to be calibrated, as far as may thus be ascertained.* With a recorder, see that a clean thin line is produced without friction, and that an accurately punched chart is used.

(3) *Test First for Leaks.* Shortly after starting a calibration there should be a long pause with the pressure on, to make sure that the pressure does not fall due to leaks *in the connections.* The slow rate of fall of the piston due to the oil film crevice being known to the operator, he can tell when there is a connection leak. Some connections in the pressure system may not be in sight.

(4) *Take Close Readings.* The proper weights being on, and the piston spinning and floating, the gage—if an indicator—should be tapped lightly and read as closely as possible. The eye should be held directly opposite the pointer in order to avoid parallax, and read closely: The reading recorded on paper by the operator should be to a fraction of a scale division—a fifth of a division in most cases. With a large gage—as the illuminated type—it could easily be to a twentieth of the regular divisions, when subdivisions have been made in pencil before calibration, but such nicety would be wasted if such a gage, after calibration, is to be re-installed ten feet above the boiler room floor, and the implied degree of accuracy would moreover be too much to expect. In short—use proper discretion.† With a recorder, the reading is autographic but the operator should rotate the chart for each reading so that the pen draws an arc at least an inch in length. The "estimate unit" in the case of most charts depends on the closeness of the printed divisions. Whether a recorder should be tapped or not depends on the purpose of the test. For a routine calibration as considered in this section, it should be; for a determination of friction effects it should not be

(c) Gage Calibration Procedure

The procedure consists in taking two series of readings at fixed intervals of pressure.

The first series starts with the least graduation of the scale and ends with the greatest graduation; the second series starts with the greatest and ends with the least. The precautions listed above *must* be strictly observed.

*See Section 15 for miscellaneous tests pertaining to acceptance inspection rather than to calibration.

†The "least reading" is a matter of judgment. For instance an otherwise good gage may be so built (or worn) that every time you tap it, the pointer comes to rest in a visibly different position. Or the top of the hand may so much broader than the contemplated "unit of estimation"—or so distant from the scale—that to read closely is like aiming a coarse-sighted rifle at a small bull's eye.

The Plant Standards *should* be operated as prescribed by the manufacturer, especially in the case of elaborate instruments.

The fixed interval between readings is optional. An interval giving eleven readings in each series is customary (i. e., 0, 10 . . . . 90, 100). With retard movements and with compound scales, an engineer will prescribe accordingly, and an experienced operator will probably not need to be told.

When a gage is desired to be calibrated very accurately "at one point only" the interval may be split up in that region. When a gage is desired to be "calibrated at one point" it should be calibrated over its entire range. There is no such thing as calibrating any instrument "at one point." That is mere "checking."

A single series of readings—ascending or descending—does not constitute a calibration test. A pair of series—ascending *and* descending—constitutes a test.

The readings may be plotted on rectangular coordinates against the true values to give the familiar loop, but for industrial plant work and even for engineering test work it is better to record them as follows. The readings in the UP column are obtained during the ascending period, from the top down. The readings in the DOWN column are obtained during the descending period, from the bottom up.

(Place) (Date) (Gage No. etc.) (Name) (Other Data)

Reading of Standard	Gage Readings UP	DOWN	MEAN	Calibration correction
0	2*	4*	3	−3
50	53	55	54	−4
. . .	. . .	. . .	. . .	. . .
450	446	450	458	+2
500	499	501	500	0

The column MEAN is computed to the nearest significant place, and from its values the calibration correction is obtained. The importance of the decision as to the "units of estimation between divisions" may now be seen: it determines the significance of the values, and it defines the tolerance.

In calibrating a recorder it is well to make a similar log, to which the chart is later attached. The reason is that for the calibration correction, a column of figures can be interpreted more readily than a chart. In taking a chart it is necessary to identify the ascending and descending records: little pencil check-marks on the arcs of the "up" record will do it. The "down" arcs are then made each alongside of the corresponding "up" arc, and the distance between those pairs of arcs as well as between each and the standard pressure circle on the scale of the chart, shows at a glance the performance of the recorder over the ten (or five, or twenty) test pressures.

For graphs and the intrepretation of loops see Chapter I or various publications of the Bureau of Standards, etc. We are concerned here only with industrial or engineering measurements of pressure, and the simple calibration procedure herein advocated is amply sufficient.

*In most gages especially in ordinary-grade gages and particularly in steam gages, there is a pin (known as the "stop") sticking up from the dial, sometimes at the true zero but more often around 1% of the scale range, which prevents the hand from coming to the true zero position, and the big zero mark on the dial doesn't mean anything

(d) Resetting the Hand

If the calibration shows that an indicating gage reads high or low by a nearly unvarying error over its entire range *or over the region where it is used*, an adjustment can readily be made by removing the pointer by means of a "hand jack" or puller such as is shown in Fig. 242, and resetting. The resetting may be done while holding pressure at a convenient point by means of the gage tester. The pointer is then to be pushed on lightly and a few points checked with increasing and decreasing pressure according to the above procedure. If the setting seems correct, the pointer is to be carefully driven on and then a complete calibration made. This final calibration is not superfluous. It is the one that "tells the story."

Fig. 242. Pointer puller or hand jack. (*Consolidated Ashcroft Hancock Co.*)

(e) Adjustment of Rate

In most cases it will be found, however, that the gage is not merely high or low, but that it is fast or slow. In other words it gains or it loses over the Standard, by an increasing error, or by a decreasing error. In the majority of such cases the movement may be slowed down or speeded up by an experienced man by adjusting the radius of a connection provided with slots for that purpose. See Section 15.

Some gages will be found to be fast over some regions and slow over other regions. In some makes this condition may be corrected by adjusting the movement. In *those* makes it may mean that an unskilled person had monkeyed with the multiple adjustment. In other makes such a condition may mean an incorrectly graduated scale—or a permanent injury.

(f) When is Calibration Complete?

The calibration is complete when the rate has been adjusted if possible, and when the hand has been reset if necessary, so that a final calibration shows that the *mean reading* of the gage is "correct," for at least a short range in the region where the gage is used. Such correctness may be defined as a limit of error within three units of the estimations decided upon between scale divisions. Thus if fifths have been decided upon, correctness means within three-fifths of a scale division. This, too, is a matter of discretion.

(g) Check for Permanence of Calibration

For accurate pressure measurement a gage should satisfy the following requirements: After completing the calibration as stated in the preceding paragraph it should be removed from the gage tester and shaken and handled in a way simulating careful use, without of course, changing the pointer or the gage rate. It should then be recalibrated as outlined above, removed and handled and shaken again, without changing pointer or gage rate, and again recalibrated. If the three calibrations agree within three units of the estimations between divisions (but only for pressures above the first thirty to fifty scale divisions) the gage is satisfactory for "accurate measurements." This does not necessarily mean that the gage will *read* correctly except for a fairly short range, but it does mean that the calibration correction will remain constant. Needless to add, this paragraph does not apply to pressure recorders, unless a powerful athlete is around.

(h) Time and Frequency of Calibration

For accurate pressure measurements in engineering tests, calibrations are preferably made both *before and after* a series of tests, and the mean of six calibrations is then used to correct the gage readings during the test. For tests extending over a considerable period, it may even be desirable to make an intermediate set of calibrations. For industrial pressure measurements, judgment must dictate the time and frequency of calibrations. When circumstances prevent frequent calibration, "checks" by connecting a standard (or a good test gage) in parallel should frequently be made between regular calibrations.

3. U-tube Forms.

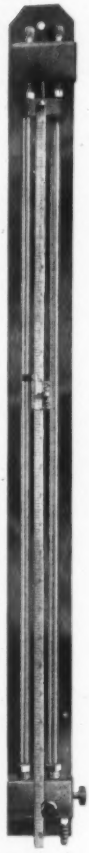
(a) Visible-liquid.

Ruggedness, and various conveniences for ease of installation and reading, distinguish the industrial double glass-leg gages. In those used for differential pressures, another characteristic is construction to withstand high line pressures. For the measurement of single pressures with one leg open to atmosphere there are various syphon models with a riser longer than the U and connected to the top of the pressure leg. Most glass tubes are protected. In many models the glass bend—a weak spot—is done away with and there are robust top and bottom headers in the design of which considerable ingenuity is displayed. Among these may be mentioned the new molded bakelite supports (American Meter Company's gages) which are adjustable to permit easy replacement of broken glass. Such a provision is mostly found in portable models. Panel backs and threaded connections feature the wall models. Matched pairs of tubes—same internal diameter and uniform bores—prevent errors that would arise from the combination of evenly-graduated scales with non-uniform tubes.

This is especially important in the case of long columns, such as the mercury gage shown in Fig. 243, in which the distance between upper and lower headers is 24 inches. In this gage, designed by Professor E. P. Culver of Princeton, the readings are taken from a silver plated brass scale, the upper end of which is attached to a rider which slides on the glass tubes and is adjusted to the level of the upper column (right tube). The lower rider is similarly adjusted to the left tube, having a vernier which permits readings to 1/100 in. The front of the gage back is chromium plated and polished to serve as a mirror and eliminate parallax. The scale is firmly held after setting by means of a thumb screw in lower header. The difference in the column height can be read directly, due to the design of the scale and rider. Of interest in connection with hydraulic differentials: Air-binding eliminated by being able to fill gage through bottom. Venting valves permit removal of any air which might become trapped at top.

Another instrument for hydraulic differentials is the inverted U-gage shown in Fig. 244, which is self-explanatory. The chief difference between this inverted type and the ordinary type is that the liquid levels in the two legs are the actual levels of the liquid measured, instead of being mercury or another special liquid placed in the U-tube itself. The main advantage is that there is no mercury to be blown over and lost.

Description of the gage shown in Fig. 245 seems almost superfluous. The range is 3 inches, hence this is a "pocket" instrument. Water may be read to 1/100 in. without setting up or leveling.



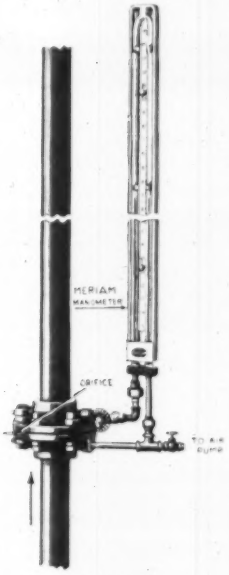


Fig. 244. Inverted U-gage for measuring liquid differentials (*The Meriam Company*).

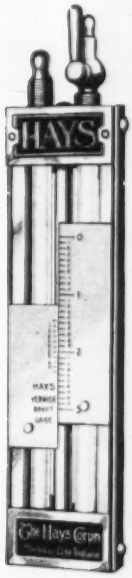


Fig. 245. Small sensitive vernier-equipped draft gage (*The Hays Corporation*).

Fig. 243. The Culver universal differential gage (*Crescent Engineering Company*).

Fig. 246. High-pressure U-gage with blow-over prevention (*Morey & Jones, Ltd.*).

INDUSTRIAL FORMS OF GLASS U-GAGES

Another high pressure mercury manometer is shown in Fig. 246. It can be furnished for pressures upwards of 1500 lb. A ball-check fitting at the top of each glass leg prevents mercury from being suddenly blown over into the pipe line, due to line surges. For pressures not exceeding 250 lb. per sq. in., this instrument is furnished with a taper plug by-pass valve, built into the head, providing a cross-over connection between the two legs, for checking the zero level. The design and construction permit of its being made of special materials for the handling of corrosive fluids.

(b) Contact Manometers.

Here we have an interesting intermediate form. The glass U-tubes are not done away with as they are in industrial pointer or pen-arm differential gages; but one may note in Figs. 247 and 249, such industrial features as an equalizing valve similar to that used in other flow meter manometers, two seal chambers filled with oil to prevent the water or other liquid in the connecting pipes from entering the manometer and short-circuiting the electric connection, etc. This gage is used for alarm purposes, or as part of automatic flow control systems, in addition to its use as a measuring instrument.

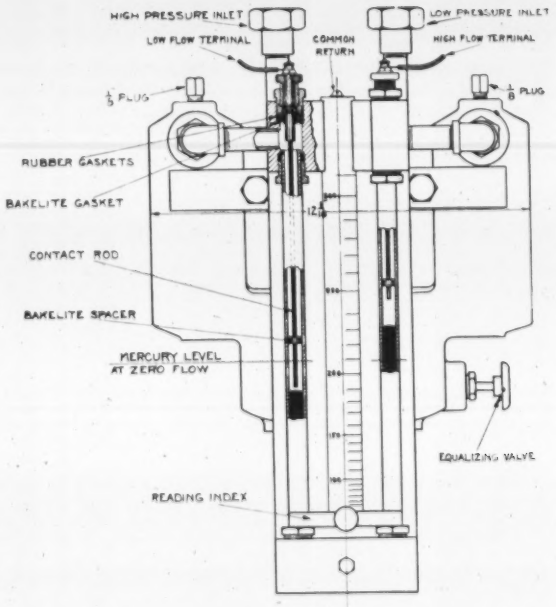


Fig. 247

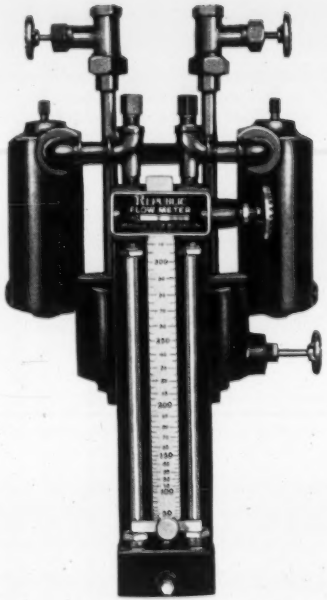


Fig. 248

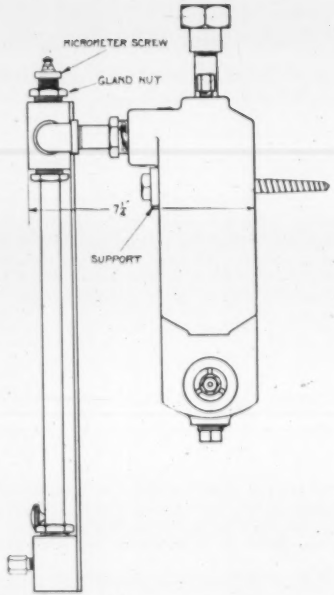


Fig. 249

A MERCURIAL DOUBLE TUBE MANOMETER WITH ELECTRIC CONTACTS IN EITHER OR BOTH LEGS

(Republic Flow Meters Company)

(c) Modified Industrial Forms.

Doing away altogether with glass tubes seems to be a necessary step in the thorough "industrialization" of the U-gage whereby it becomes a flow meter manometer. Considerable ingenuity is displayed in the dozens of different designs on the market. These are essentially *pressure* measuring instruments but their discussion belongs under flow measurement and control.

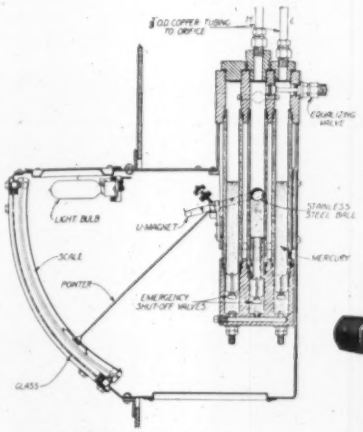


Fig. 250. Modified U-gage for indicating differential. (*Bailey Meter Company*).

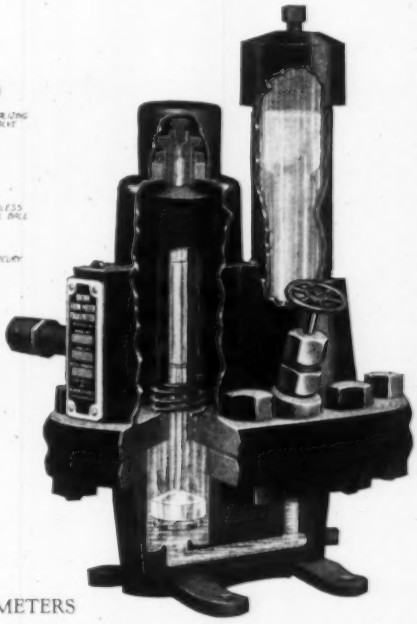


Fig. 251. Modified U-gage. Non-indicating electric transmitter. (*Brown Instrument Company*).

MODIFIED U-GAGES FOR FLOW METERS

As Fig. 250 shows, this differential indicating instrument is of the boiler panel type. A top view (not shown) would bring out its narrow construction which permits it to fill one space in a "multi-pointer" assembly of individual instruments arranged into one uniform row of illuminated "end-on" scales. (For a typical multi-pointer gage see Fig. 335). The U-tube is mercury-filled and has three legs of uniform diameter in order that the mercury level will change more in the center or measuring leg than in the others.

For "television" purposes as required on many modern industrial applications, electrical long distance transmitting systems have been developed in which the measuring instruments, instead of—or in addition to—operating a pointer or pen-arm, transmit electrical impulses. A non-indicating manometer transmitter—for pressure, liquid level, etc.—is shown in Fig. 251. A float rests on the surface of the mercury. The float carries a non-magnetic rod, to the upper end of which is fixed a magnetic arm moving freely up and down a pressure-tight non-magnetic tube. Over the outside of this tube is slipped a divided inductance coil. (For details see Fig. 341.)

Space limitations prevent showing other ingenious forms.

Another modification of the U-gage is dealt with in Section 8, heading (*b*).

(d) Multiple U-gages.

By connecting a number of U-gages in series, one obtains the equivalent of one U-gage of greater length than can be accommodated in an ordinary building. Mercury is generally used, with water in the top connections (successive bodies of air or gas would compress progressively and complicate readings, beside bringing in greater temperature corrections). The author knows not a single reason why such instruments could be used in industry in preference to loaded piston gages. The Bureau of Standards, however, uses one such instrument of extreme accuracy, concerning which a paper is to be issued shortly.

4. Single Tube Forms.

Strictly speaking, the only single-*column* type of instrument is the type illustrated in Figs. 270 and 271. The other single *tube* instruments are not single column manometers or gages, but modifications of the two-column or U-gage in which, for the sake of convenience, one leg is a large reservoir—also called a chamber, cistern or well—and the other leg is a comparatively narrow-bore tube which is graduated. The graduations are not etched on the tube itself, in the commercial forms, but appear on a scale next to the tube. The scale is generally adjustable up and down, to facilitate zero setting. In some of the industrial instruments, this scale is moreover direct-reading, that is to say it is corrected for the ratio of the diameters of the two legs and is adjusted only when the volume of liquid has been changed. In other instruments the scale, *graduated in true linear units*, is adjusted whenever a reading is taken—its zero point being made to coincide with the level of the liquid in the cistern. In instruments filled with liquids other than water the scale may also be compensated for specific gravity as well as chamber displacement, to read inches of water.* Scales graduated in pounds and ounces, pounds and tenths, ounces and tenths, etc.,—all per sq. in.—are also carried in stock by several makers. Square root scales are of course the ones provided as a rule when the instruments are to measure differentials across the primary elements of flowmeters.

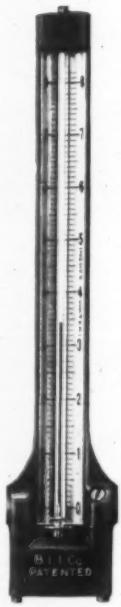
There are two important advantages: (1) The scales are more open: with a cistern having an area 250 times that of the tube bore, an ordinary inch scale will give direct readings with a negligible error without being reset. (2) Only one scale to read.

(a) Vertical Tube.

To this group of instruments—all of single vertical tube forms—there belong numerous types, to which it is impossible to do justice in the confines of this section. Considering however, the industrial applications, there may be singled out the mercurical vacuum and absolute pressure gages.

A representative direct-reading manometer with large reservoir is shown in Fig. 252. The reading scale is placed between the glass tube and the semi-circular frame, with divisions running from one side to the other, as may be seen on the illustration. For low ranges, oil is used with an aluminum manometer frame; for higher ranges mercury, with cast iron frame. Double scales are featured, reading inches on one side and ounces on the other. Pressure connection is made at the back to the reservoir, and the top of the glass tube is open to atmosphere, so that gage pressure is indicated; but with other arrangements the gage can read vacuum or differential.

*"The use of oil in draft gages for the indicating liquid, together with this compensating feature, was devised and introduced by Lewis M. Ellison."



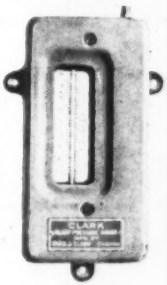
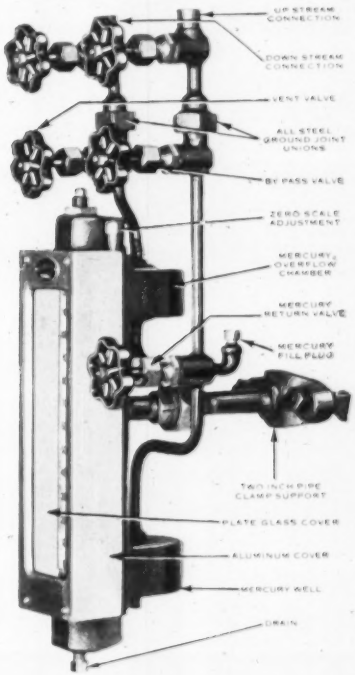


Fig. 253
C. J. Clark
Blast Meter
Company

Fig. 252.
Bacharach
Industrial
Instrument
Company.

Fig. 254
The Meriam
Company



INDUSTRIAL
SINGLE VERTICAL TUBE
MANOMETERS

The scale of the Blast Pressure Gage, Fig. 253, "is of nickel silver. Each scale is hand divided, to be correct for the particular gage it is to fit . . . unavoidable variations in the bore of glass tubes." Other features are large tubes with a liberal quantity of mercury, several coats of baked enamel, etc.

Mercury blow-over into the pipe line is prevented in the line of instruments of which Fig. 254 shows one. Other features are lettered on the illustration. An attractive possibility with some of the models is panel board installation with only the rectangular case and hand-valves showing.

Among the many other interesting forms of well-type direct-reading vertical tube gages, there may be mentioned the multi-tube instruments in which several gages are assembled in a rectangular case. The author was pleasantly impressed with one comprising five gages—large tubes filled with red oil and readable at quite a distance on one white enameled scale running clear across the back of the tubes.

Mercurial vacuum gages of the open-cistern type are shown in Figs. 255, 256 and 257, the first and third showing also the trap or catchall which is a necessary adjunct wherever there is danger that liquid will be carried over to the space above the mercury in the tube. The true barometric type is shown in Fig. 255, which in fact embodies a high-grade mercurical barometer constructed exactly like the "Observatory pattern" described in Chapter X (Fig. 215). Such instruments can be used for very close work, as in tests. Some have verniers, reading to 0.001 in. and by using them together with the corresponding barometers, corrections cancel out.

Fig. 256 shows a gage housed in a cylindrical steel case with bronze-framed plate glass front. The tube is ½ in. internal diameter and having no bends is easily cleaned. The cistern can be removed readily for cleaning and filling.

Fig. 255

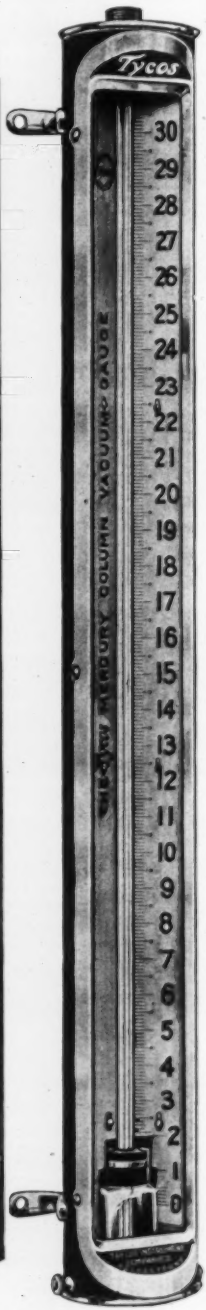


Fig. 256

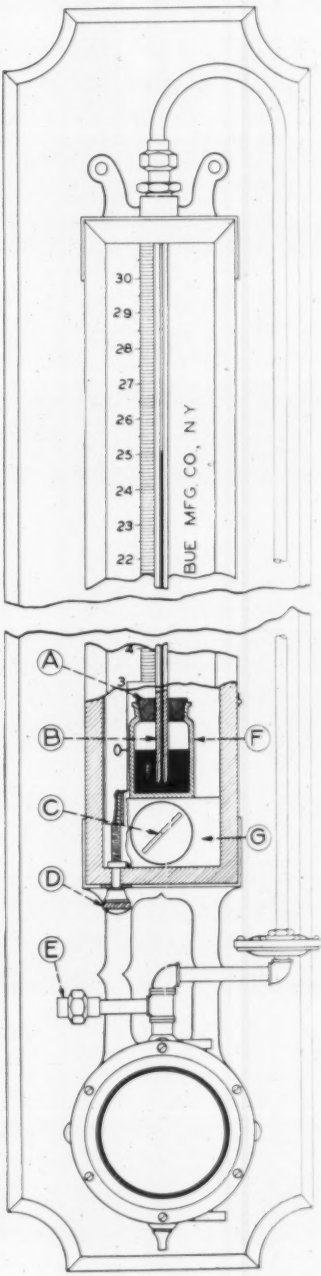


Fig. 257

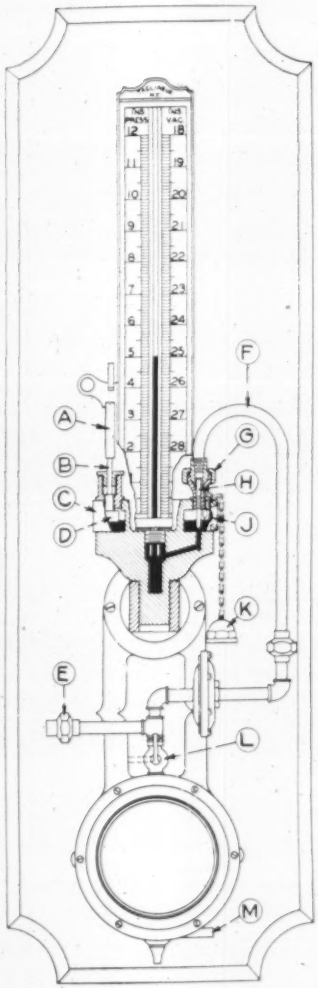


Fig. 258. Mercurial absolute-pressure gage. (C. J. Tagliabue Mfg. Co.)

On facing page

BAROMETRIC TYPE MERCURIAL OPEN-CISTERN VACUUM GAGES

Figs. 255 & 256, *Taylor Instrument Companies*; Fig. 257, *C. J. Tagliabue Mfg. Co.*

Except for a rectangular instead of a round case, and for other minor features, the same description can apply to the gage part of the instrument shown in Fig. 257, which is further described by the following extracts from the maker's directions:

Connecting Gage—After securely mounting the gage, connect union E to the vacuum line. Do not apply white lead to the pipe connections on the gage, as these are furnished with ground seats and soldered threads, and are air tight. Connections in the vacuum line must be leaded, as well as the nipple connecting gage to line.

Filling Cistern with Mercury—Disengage thumbscrew C and remove wooden block G and bottle F into which pour sufficient mercury to raise the level to the zero scale division when the bottle has been again installed in the gage. After returning bottle and block to their original positions, insert glass tube B nearly to the bottom of the bottle. Stopper A is not made air tight, as atmospheric pressure must act on the surface of the mercury in the bottle.

Setting Zero—Turn knurled adjusting knob D until zero on scale coincides with level of mercury in bottle.

In the *absolute pressure* type of vacuum gage, Fig. 258, the upper end of the glass tube is closed and the tube has been exhausted at the factory so that with atmospheric pressure acting on the reservoir C the mercury fills the tube. When the instrument is ready for use as shown and with union E connected to the vacuum apparatus, the absolute pressure may be read directly on the scale.

Fig. 258 shows gage, panel and trap assembled. As received, sealing cap K is on instead of vacuum connection G. After K is removed, sealing screw H is loosened, opening a passage between reservoir C and the tube. When this has been done, G is then permanently connected. Mercury level is adjusted by turning spindle B with clock key A, raising or lowering plunger D and displacing more or less mercury until the mercury level touches the ivory-pointer visible through sight glass J.

Draining the Trap is accomplished by turning the handle of cock L from the normal vertical position, to the horizontal position indicated by the dotted lines. As the cock has a three way feature, this quarter turn simultaneously closes the passage to the gage and opens the trap to atmospheric pressure, permitting the moisture to drain off, when petcock M has been opened. Petcock M should be closed before returning the handle of cock L to the original upright position.

INDUSTRIAL FORMS OF INCLINED TUBE GAGES

(Ellison Draft Gage Co.)

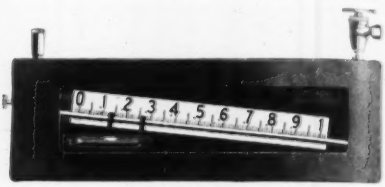


Fig. 259

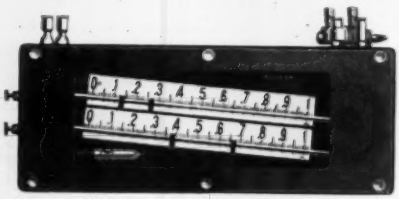


Fig. 260

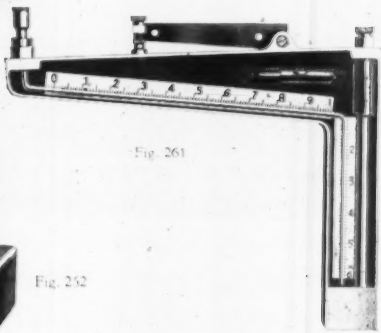


Fig. 261

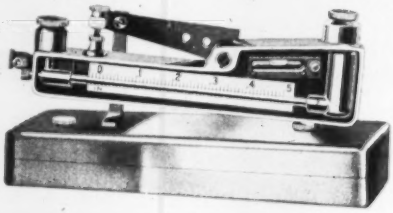


Fig. 262

(b) Inclined Tube.

The principle of the inclined tube gage is simple enough not to require a diagram. Let A be the area of the reservoir and a that of the tube bore. As pressure is applied to one leg, say the reservoir, the level there drops over a small distance, h_1, while the level in the tube rises over the vertical distance h_2 of which the inclined component (the travel of the liquid up the tube) is D. Let α be the angle of the tube to the horizontal. The sum of h_1 and h_2 obviously represents the head H corresponding to the measured pressure, for h_1 and h_2 are always in opposite directions from zero level. The multiplication factor of the gage, then, or D/H, $= 1/[\sin \alpha + (a/A)]$.

In the industrial instruments the usual maximum multiplication is 10. A greater sensitivity would often be accompanied by sluggishness, and slight inaccuracies in tube bore or in leveling would cause serious errors.

Of the several industrial makes, the oldest is selected; and of its instruments, four are shown. Fig. 259 is a ten-inch gage with a one-inch water range—the actual liquid however being a light petroleum oil of fixed gravity and satisfactory surface-tension characteristics. As many as four gages can be assembled into one multiple instrument. Fig. 260 shows a two-tube draft gage for furnace and flue drafts with zero ends of tubes open to atmosphere. An inclined-vertical gage for air and gases, for suction, pressure or differential, is shown in Fig. 261. The scales read water head. A light and compact outfit, Fig. 262, features micrometer scale adjustment, etc.

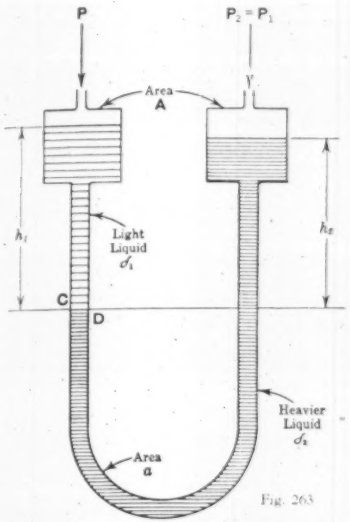


Fig. 263

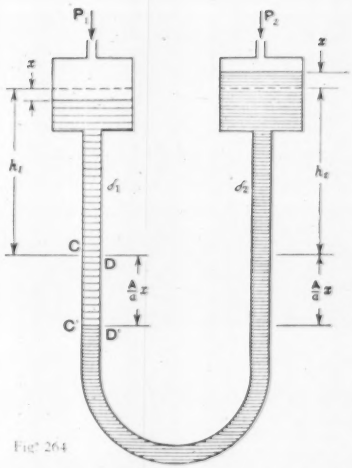


Fig. 264

5. Micromanometers.

Precision forms of pressure measuring instruments are variously known as micromanometers, multiplying manometers, etc. We include here the differential liquid manometers and inasmuch as the instruments to be dealt with in this section are not strictly industrial, mention is first made of the Bacharach differential liquid manometer which is an industrial instrument. The large leg is the reservoir while the other leg is of "medium" diameter at the bottom and of small diameter above. Mercury falls a short distance in the reservoir and rises a greater distance in the "medium" section, expelling oil a still greater distance up the narrow bore above.

There occasionally come up in plants questions requiring very accurate measurement of low pressure, draft or differential. Seldom is there time for selecting and obtaining a micromanometer (not to mention putting through the appropriation). Knowledge of the differential liquid principle makes it possible to contrive a micromanometer exactly suited to the application involved. The clearest "working explanation" is that in Experimental Mechanical Engineering by Diederichs and Andrae:

The two legs of the U-tube, Fig. 263, of area a, are enlarged near the top into two reservoirs, each of cross-sectional, area $= A$. The heavier liquid of density z_2 fills the right-hand side and the left-hand side to the contact surface CD, with the lighter liquid of density z_1 above CD. The two liquids must of course be non-miscible, and, since the reading consists in determining the motion of the contact surface CD, the latter must be clearly defined.

With impressed pressure P_1 and P_2 equal (Fig. 263), the contact surface will take a position so that $h_1\delta_1 = h_2\delta_2$. If now pressure P_1 is greater than P_2 by an amount $= \triangle P$ (Fig. 264), the level will fall a distance x in the left-hand reservoir and rise the same distance on the right-hand. But the motion of CD downward to a new equalization position $C'D'$ will equal a distance $\frac{A}{a} - x$. For the equilibrium condition we may now write, measuring all distances above $C'D'$,

$$P_1 + h_1\delta_1 - x\delta_1 + \frac{A}{a}x\delta_1 = P_2 + h_2\delta_2 + x\delta_2 + \frac{A}{a}x\delta_2$$

The impressed pressure will then be, since $h_1\delta_1 = h_2\delta_2$

$$\triangle P = P_1 - P_2 = \frac{A}{a} x \left\{ (\delta_2 + \delta_1) \frac{A}{a} + (\delta_2 - \delta_1) \right\}$$

The observed magnitude is $\frac{A}{a} x$, the other factors are constants of the instrument.

The multiplication factor of the instrument is

$$\frac{\frac{A}{a} x}{\triangle P} = \frac{1}{(\delta_2 + \delta_1)\frac{a}{A} + (\delta_2 - \delta_1)}$$

This will be the greater, the smaller the value of $\frac{a}{A}$ and the smaller the difference $\delta_2 - \delta_1$.

A favorite pair of manometer liquids for the mutiplying manometer is kerosene and alcohol. Where both liquids are naturally water-white, one must be colored. See Chapter X, Section 5. Assuming that the ratio of $\frac{A}{a} = 1000$, and that δ_1 for alcohol $= 0.80$, δ_2 for kerosene $= 0.81$, we shall have a multiplying factor of approximately 86.1. This can be materially increased by decreasing $\delta_2 - \delta_1$. It may be necessary to mix several liquids to obtain the desired relation between δ_2 and δ_1. It is in general better to determine the factor by actual calibration against known pressures.

A modification of this manometer is shown in Fig. 265. Here the heavier liquid partly fills the U-tube, the lighter liquid resting on top on both sides. A cross-connection with a valve serves to equalize the lighter liquid on the two sides with the manometer open to the atmosphere. Closing the cross-connection and impressing a pressure say on the left side, causes a movement downward of the contact surface on that side a distance $-x$, and an equal rise of the contact surface in the right leg. The observed magnitude is $2-x$. The equation for this manometer is

$$\triangle P = 2\frac{A}{a} x \left\{ \delta_1 - \frac{a}{A} + (\delta_2 - \delta_1) \right\}$$

and the multiplying factor is

$$\frac{2\frac{A}{a} x}{\triangle P} = \frac{1}{\delta_1 \frac{a}{A} + (\delta_2 - \delta_1)}$$

For the same conditions as previously assumed, this gives a factor of 92.6. There is consequently no great difference in the sensitivity of the two types, but the former is to be preferred because it requires the observation of only one level, which is of advantage with fluctuating pressures.

Of all micromanometers on the market, it would seem that the most "industrial"—rugged, fool-proof, etc.—is one which unfortunately comes at present only in metric graduations, being of German make. That is not a big objection and the Minimeter, Fig. 266, deserves inclusion here. Extracts from the maker's description follow:

The Askania Minimeter is a water column micro-gage accurate to within 1/100 of a millimetre of water column. The principle upon which it is based is the use of two intercommunicating containers, one of which is raised until the difference in height between the two water levels balances the pressure that is being measured. When taking readings, the surface of the water is brought to the true zero position by sighting a gilt pointer located in the water, the image of the pointer being reflected by the surface of the water. The height of water at which the extremity of the pointer just touches its reflection can be determined with the aid of a mirror to within 1/100th of a millimetre. The total range is 120 millimetres, pressure or differential.

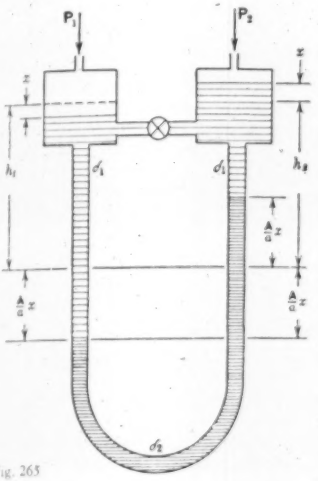


Fig. 265

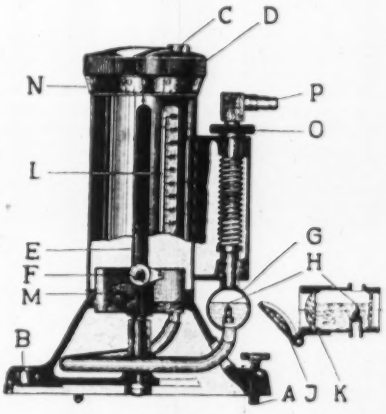


Fig. 266. The Minimeter
(*American Askania Corp.*)

To use the Water Column Minimeter, the instrument must first of all be set truly horizontal by means of the levelling screws A and the level B which is let into the base of the instrument. Bring the pointer F to zero and admit water through the nipple P until the surface of the water is about level with the extremity of the pointer H, which can then be brought dead level with the surface, that is to say, to the zero position, by turning the screw O until the pointer H, when seen in the mirror J and magnified by the lens K, just touches its reflected image.

The pressure to be gaged is then connected up to the nipple P by means of a length of rubber tubing; if differential is to be determined, the lower pressure is connected to F. As soon as the pressure is on, the level of the water in the sighting container G will fall and the equalizing container M must then be raised by turning the knob C or the milled ring D to which it is connected, until the surface of the water has resumed its original level, i. e. until the pointer H again touches its reflected image, when the pressure in millimeters of water column can be read off on the scale L or on the fine division scale N. The latter has 200 subdivisions, each sub-division representing the one-hundredth part of a millimetre so that one complete revolution of this scale represents two millimetres of water column.

Adhesion and surface tension of the measuring medium do not affect the Askania Minimeter, because the surface of the water is level when the reflection is adjusted and the reading taken. The correction required for temperature can be deduced from the difference between the expansion of the gage spindle and the expansion of the water, but as the coefficients of expansion of water and of brass are very small, the necessary correction in most cases will be less than 1/100 th of a millimetre, so that the accuracy of the gage is not affected. It is immaterial whether the containers are of the same width or not, because the surface of the water is always brought back to the same level for each reading. Thus, whatever form the pressure may assume it is immediately converted into water column. The steadying effect of the tube connecting the containers is so pronounced that it will suffice for most purposes. If the pressure fluctuates very much, this steadying effect can be intensified at will by compressing the tube.

The best known commercial micromanometers for laboratory use are at present the Chattock, the Whalen and the Krell (the McLeod is a vacuum gage). They will be found described in the Handbook of Laboratory Instruments and Apparatus by Schroder. A brief extract on the Chattock Gage may be in order.

The instrument is similar in principle to a U tube, the difference of pressure on the surfaces of the water in the two legs of the tube being measured by tilting the gage through a small angle, so that there is no displacement of water along the tube. Errors due to capillarity and viscosity are thus avoided. The glass U tube of unusual form (see Fig. 267) is mounted on a metal frame, the tilt of which can be varied by a micrometer screw. The left leg of the

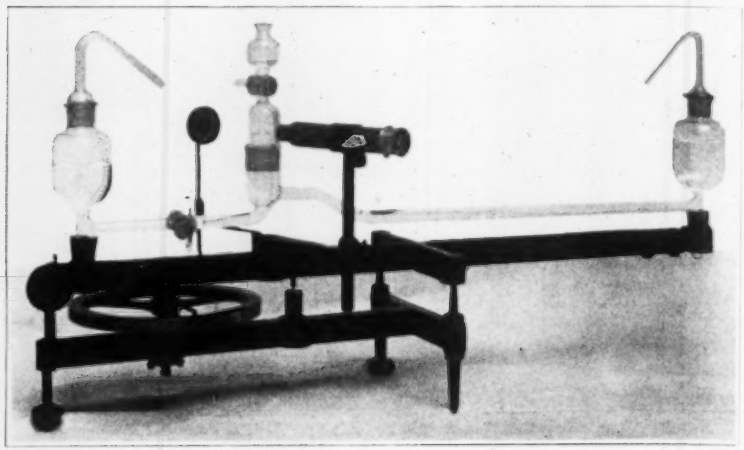


Fig. 267. Chattock Gage (*Cambridge Instrument Co.*)

U tube is continued upwards into, and is concentric with, the central vessel, to which the right limb is connected. This vessel is filled with oil and water, and communicates through a tap at its upper extremity with an oil reservoir. The surface of separation of the oil and the water, which is formed at the upper extremity of the left leg inside the central vessel is illuminated by a small mirror, and its position is observed by means of a microscope attached to the frame. Any alteration in the difference of pressure in the two vessels forming the extremities of the U tube causes a displacement of the separation surface, which is kept in coincidence with the cross wire of the microscope by rotating the micrometer head.

The dimensions of the gage are such that one revolution of the micrometer screw corresponds to a pressure difference of 0.0255 inch of water. The micrometer scale has 100 divisions, and a movement corresponding to one quarter of a scale division can be detected by the microscope, enabling the pressure difference to be observed to 0.00006 inch of water. The micrometer screw is fitted with a large flywheel, which enables the gage to be tilted with considerable rapidity.

A super-micromanometer, ten times as sensitive as the commercial Whalen and Chattock gages, i. e., reading to the hundred-thousandth of an inch of water, was designed by J. L. Hodgson. Those built have given excellent results. This instrument is rugged enough (see Fig. 268) to be classed as industrial. The designer, a noted English physicist, and member of the staff of *Instruments*, described it in the April, 1929 issue.

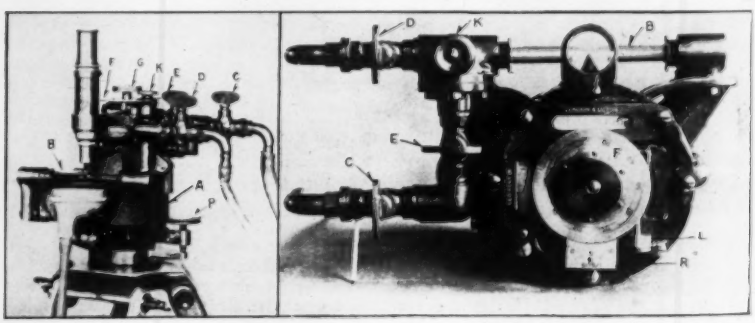
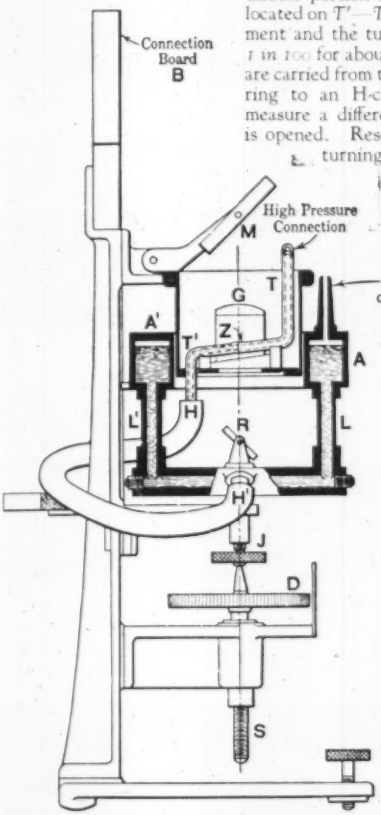
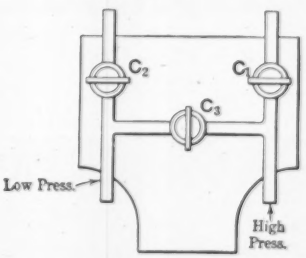


Fig. 268. Super-micromanometer of J. L. Hodgson

An instrument to which the author has taken a strong fancy and which would seem to lend itself to "industrialization" is the micromanometer designed by Prof. Ernsberger of Cornell and shown in Fig. 269.

It is essentially a cistern type of manometer utilizing the *null method* of indication. The annular ring A—A' is the reservoir. The two legs of a U-tube L—L' are tapped into diametrically opposite sides of A—A'. From the bottom of the U-tube a flexible rubber tube H'—H connects to a bent glass tube T'—T. The ends of T'—T are vertical but the middle portion has a slope of 1 in 10. An index line Z is located on T'—T where it crosses the center line of the instrument and the tube is kinked so as to have a slope of about 1 in 100 for about $\frac{1}{8}$ in. each side of the index mark. Leads are carried from the end of the glass tube and from the annular ring to an H-connection shown below. When used to measure a differential, cocks C_1 and C_2 are closed and C_3 is opened. Reservoir A—A' is then raised or lowered by turning micrometer screw S until the meniscus of the liquid in T'—T stands at the index mark Z. This is observed by reflection in mirror M through reading glass G. When this adjustment has been made and the reading of graduated disk D has been noted, cocks C_1 and C_2 are opened and C_3 closed. The higher pressure acting in tube T'—T will drive the liquid down that tube and into reservoir A—A'. This reservoir is then raised by screw S until the liquid is again brought back to reference mark Z. The amount necessary to raise reservoir A—A' is a direct measurement of the differential to be measured.





When used to measure a pressure rather than a differential, the cock C_2 is left open to the atmosphere at all times. Otherwise the procedure is the same.

The advantages of this instrument are: (1) the inherent accuracy of the null methods of measurement, (2) the simplicity of a single liquid and single indicating surface, (3) stability of the indications under slight disturbances of level and (4) ability to repeat readings to the accuracy to which the micrometer can be read, usually 0.0001 in.

Compression Manometers—The principle, compressing a volume of gas in a closed-end glass tube, was discussed in Chapter X and its limitations pointed out. A successful application of this principle is found in the McLeod Gage. This being used principally for measurement of high vacua, it is described in Section 18.

6. Combination Plunger and Liquid Column

If one examines only Fig. 270, he will class the instrument as a liquid column manometer. If he turns to Fig. 271 and covers the upper part with his hand he will opine that a piston gage is shown in partial section. This instrument is in fact a liquid-column-loaded piston gage, akin to those in the next section that are loaded gravitationally (with dead weights, scale beams and weights, and pendulums), but no kin to the above-described liquid columns nor to the spring-loaded piston gages. This is a true gravitational instrument. There is no appreciable "diaphragm effect." The maximum travel of the differential plunger is 0.02 inch. The pressure acting under the plunger is balanced (within a limit of error comparable to that of other gravitational instruments) by the head of mercury over the area of the large diameter plus a constant value due to the weights of the moving parts. Theoretically it is a "primary standard" which can be calibrated by itself. As built, with features designed for industrial service, its scale is graduated against a primary standard, but the calibration is permanent—so permanent, from all reports, that such an instrument is advisably used as a Plant Standard for calibrating tube gages—not only by users but by makers of tube gages. Its first cost, by the way, greatly exceeds that of the tube gages of equal range which it is replacing in considerable

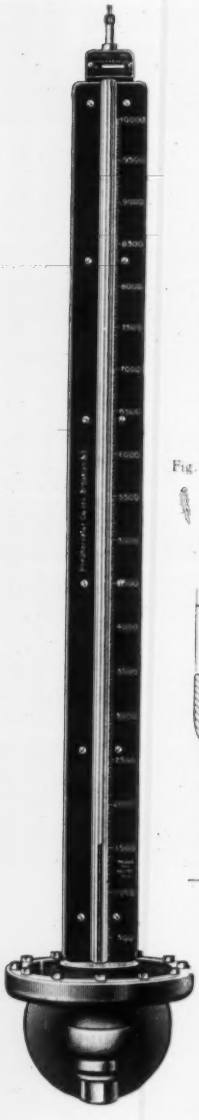


Fig. 270

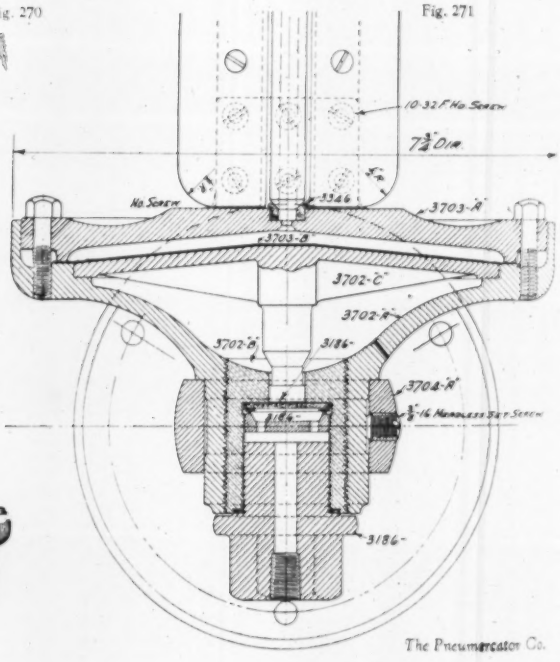


Fig. 271

The Pneumercator Co.

numbers. This instrument comes in ranges up to 25,000 lb. per sq. in., the minimum reading being from 2% to 4% of the maximum. The mercury column is 36 inches in all ranges—only the diameter of the small plunger varying according to the maximum pressure for which an individual gage is built. Accuracy is the same at all points—there is no "preferred region." Fluctuations cause no injury and are damped out especially at frequencies higher than two cycles per second. The usual temperature correction for a mercury column of uniform cross-sectional area does not apply: a greater correction is required, the table for which is supplied by the makers. A water or glycerin seal must be used with fluids liable to attack the rubber of the lower diaphragm.

7. Weight Loaded Piston.

Loaded piston gages are divided into weight loaded and spring loaded. The latter come under elastic deformation. The former, here considered, are divided according to the method of loading: (*a*) dead weight, (*b*) scale beam, and (*c*) pendulum.

(a) Dead Weight Gages.

Dead weight testers, such as those described in Section 1, heading (*d*), all comprise a gage portion in addition to the pump and other appurtenances related to testing. Such gages can only be used for the measurement of steady pressures. Even slight variations preclude their use. Their advantage is *extreme accuracy*. The Bureau of Standards will shortly issue a paper describing a group of weight-loaded piston gages constructed and used there, concerning which the following may serve as an unofficial abstract:

> These piston gages were calibrated both as absolute instruments by means of measurements of the piston diameter and width of crevice, and as secondary instruments by direct comparison with a quintuple U-gage (15 bar differential mercury manometer). Slight irregularities in the forms of pistons and cylinders, as well as the tendency of the piston to descend on account of oil leakage, impair the accuracy of the absolute calibration, but in the gages here considered the effect of the irregularities is exceedingly slight, and that of the leakage is entirely negligible.
>
> It is concluded that (1) on account of secular changes in the dimensions of steel, the piston gages require occasional calibration when an accuracy better than 3 or 4 parts in 10,000 is desired, (2) the absolute calibration, although not as accurate as the direct comparison with the manometer, agrees with the latter method within 2 or 3 parts in 10,000, (3) the piston gages are sensitive to 3 or 4 parts in 100,000 and could probably be used with that accuracy if secular changes in the steel were eliminated, (4) the effective area is not affected by the rotation of the piston, (5) the change in effective area with pressure is less than the experimental error of measurement.

(b) Fluid Pressure Scales.

The same remarks apply. See Section 1, heading (*e*). Slight fluctuations in the measured pressure do not preclude their use.

(c) Pendulum Manometers.

As mentioned in Section 1, heading (*f*) this instrument is more of a gage than a gage tester. Figs. 272 and 273 show the construction of the Amsler instrument in its standard form for use with a testing machine—that of a dynamometer with a recording drum 13 along which pencil 12 travels in proportion to the pressure (load on test bar) while thread 17 rotates the drum in proportion to the deformation undergone by the test bar.

From pipe 1 the pressure of oil is led by pipe 3 to cylinder 4 in which the measuring piston 5 moves. The communication between pipe 1 and pipe 3 is always open and cannot be cut off. This arrangement ensures that piston 5 is always subjected to the same pressure as that which is to be measured.

Under the influence of this pressure, piston 5 produces an inclination of the pendulum by means of connecting rods 7, through cross yoke 8 and lever 9 which is secured to spindle 10 of the pendulum. The pendulum is inclined until the reaction on piston 5 due to the pendulum's inclination exactly balances the action of the oil pressure on the piston. The inclination of the pendulum is then communicated by arm 16 to a moving pointer in front of dial 11 which is graduated. The pendulum on being inclined, also moves pencil 12 along the surface of the recording drum 13.

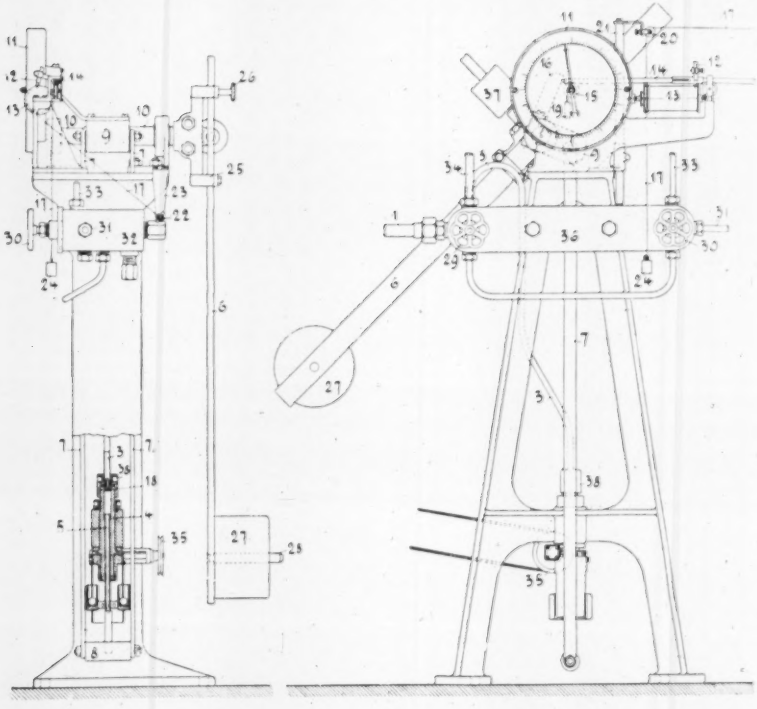


Fig. 272 Fig. 273

Amsler Pendulum Gage (*Herman A. Holz, Amer. repr.*)

Pendulum rod 6 is loaded with weight 27, which is slipped on to pin 28. Pendulum rod 6 can slide in the loop 25, and it is held in place with the pin 26. The pendulum is arranged as a rule for four different ranges which are $^1/_5$, $^1/_{10}$ one-half and the whole of the maximum load of the machine. To change from one range to another, it is only necessary to move the whole pendulum rod 6 in its fixing loop 25 and to fasten it in the suitable position by means of pin 26. The pendulum rod is therefore provided with four holes through which the pin 26 may be passed; each hole is engraved with the number indicating the range to which it corresponds. For the greatest sensitivity the weight 27 is taken off.

A by-pass return valve 18 is fixed in the connection 38, to prevent the pendulum from falling back to the vertical position too quickly when pressure is released.

Measuring piston 5 is rotated by means of pulley 35, so as to eliminate almost completely any friction which might exist between the piston and its cylinder. The rotation of the piston 5 is so accomplished that the piston is subjected to no sidewise or axial force whatever, it is only acted on by a couple. Generally pulley 35 is driven off the cam shaft of the oil pump used for working the testing machine. But an electric motor may be used, or a hand operation crank may be mounted on crosspiece 36.

8. Inverted Bell, and Miscellaneous Gravitational

We now return to more familiar forms, seen in almost every boiler room.

The group of instruments here considered includes modified U-gages which in principle belong in Section 3, heading (c), but in construction, general appearance and applicability resemble inverted bell gages much more than they do the U-tube prototype, as a glance at Figs. 286 and 287 shows.

Most of the instruments dealt with in this section are for low pressures—either positive or negative. Most are draft gages or gas gages, for such applications as pit, furnace, uptake, various passes, economizer inlet, outlet or differential, preheater inlet, outlet or differential, burner pressure, etc., etc.

(a) Inverted Bell

A tube passes through the sealing liquid to the inside of the bell and is connected to the measured positive or negative pressure. If the other end of this tube were open to the atmosphere, a "plain" inverted bell with solid metal wall, without counterweight, and sealed in water, oil or kerosene, would *sink*, because a unit section of its wall weighs more than the liquid it displaces. Conversely, a base-metal wall will be buoyed up by mercury, or a hollow wall acting as an air chamber will also float the bell in water or other light liquid.

It is simply an application of the Archimedes principle.

In any case, though, a plus pressure inside the bell will cause the inside liquid level to be lower than that outside; and draft will raise this liquid level.

Instead of, or in addition to, being buoyed, a bell may be counterweighted so as to compensate for varying immersion—the counterweight being proportionately submerged in the sealing liquid.

Pressure or suction is measured by gravitational loading of the bell, by opposing weights greater than exactly-balancing counterweights, by systems of calibrated weights together with pendulums, levers and other mechanical movements designed to make evenly-graduated scales possible, etc.

These few and simple principles have led, since more than a century ago, to the invention of hundreds of different instrument mechanisms, first in Europe and, in more recent decades, in this country. There, the trend seems to have been toward large and fancy delicate instruments; here, it is toward small, plain, standardized gages. Some English and German inverted-bell instruments are compensated for almost every possible error and are sufficiently sensitive and accurate for precision measurements. American gages of standardized commercial forms are not far behind in intrinsic accuracy, and certainly are preferable for industrial purposes.

Visibility seems on the whole to be the prime requisite in this group of industrial instruments. If a pointer gage for zero to one inch water head has a ten-inch illuminated scale that can be read twenty feet away to the twentieth of an inch of water, that alone gives it an advantage even over an inclined-tube red-oil gage; and from the standpoint of usefulness to the boiler room crew it undoubtedly is a better investment than a water U-tube costing one-twentieth as much.

Indicators (pointer gages) are shown on the next two pages; recorders on page 84.

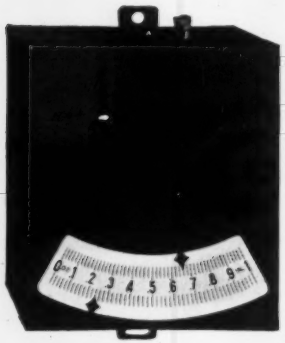


Fig. 274

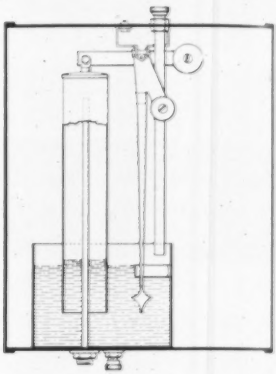
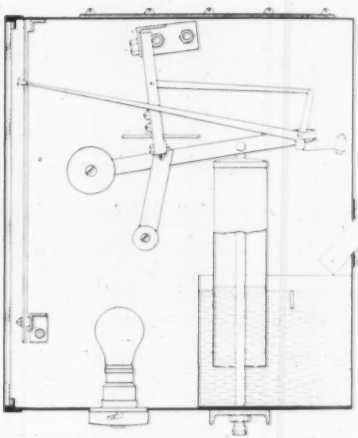


Fig. 275

Fig. 276

Fig. 277



PENDULUM-LOADED INVERTED BELL AND

Figs. 274-277 *Ellison Draft Gage Co.*

The four styles of pointer instruments are shown above, across the two pages: (1) the square or "fan" shaped case with quadrant scale, (2) the "straight-line" vertical edgewise, (3) the convex vertical edgewise, and (4) the round-dial with either a full-circle scale or the more usual 300° scale.

The dial type pointer draft gage shown in Figs. 274 and 275 is made in one or two pointer cases and in 0 to 5 inch water and 0 to 8 inch water, minus or plus (in the 6, 7 and 8-in. ranges a well extends 3¾ in. below the case). The bell has a displacement of 8 cu. in. The ratio of pointer movement to bell travel is 5 to 1. The liquid is a light gravity mineral oil for the usual boiler room temperatures; for low temperatures a low gravity kerosene.

The "straight-line" movement (Figs. 276 and 277), consists of "a system of correlated levers with an incremental gravity loading mathematically correct in relationship, thereby providing a pointer movement that gives

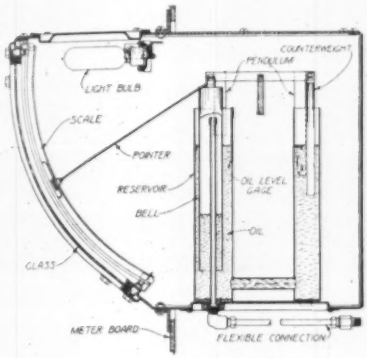


Fig. 278

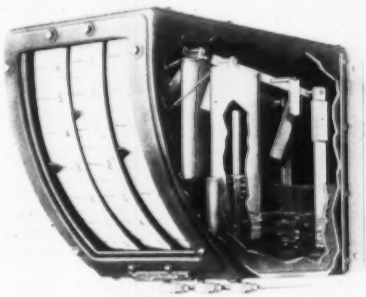


Fig. 279

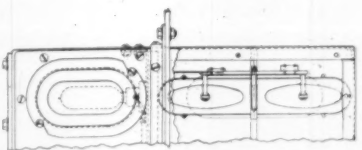


Fig. 280

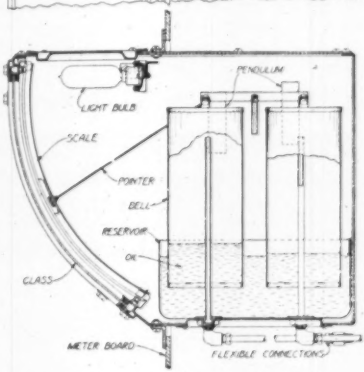


Fig. 281

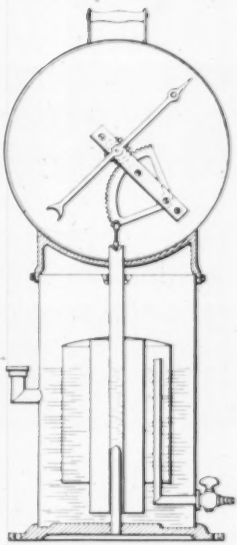


Fig. 282

AIR-CHAMBER BELL PRESSURE INDICATORS

Figs. 278-281 *Bailey Meter Co.*, Fig. 282 *Bacharach Industrial Instrument Co.*

a true arithmetical indication of the actuating pressure over the entire range of a straight-line scale of uniform spacings." The bell is of 10 cu. in. displacement for the 1 and 1½-in. range gages, 2¼-in. diameter by 2½-in. travel. For the 0.6 in. range gage the bell has a 2¾-in. diameter and 15 cu. in. displacement. The ratio of bell travel to pointer movement gives a multiplication of 4 to 1. Areas of bell and pan are so proportioned that the gage can be refilled, under full draft range, without disconnecting pipe lines and without affecting the reading by more than 0.001 in. in the average ranges. Liquid level can be observed through the filler tube; the top edge of the bar (seen in cross section) is the normal level and the bottom edge the low level. A plate glass window in the case admits light for viewing the liquid level.

The general type of multi-pointer casing shown in Figs. 278 to 281 comes in three styles: wall mounting (Fig. 279), semi-flush front or panel-board

Fig. 283
Wall-Type

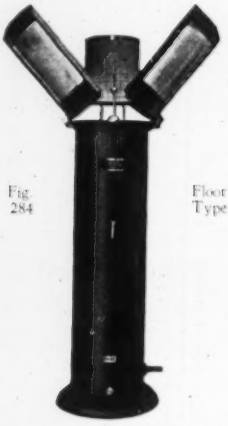


Fig. 284 Floor Type

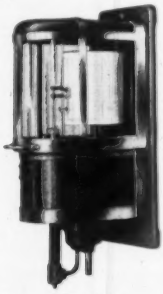


Fig. 285
Wall Type

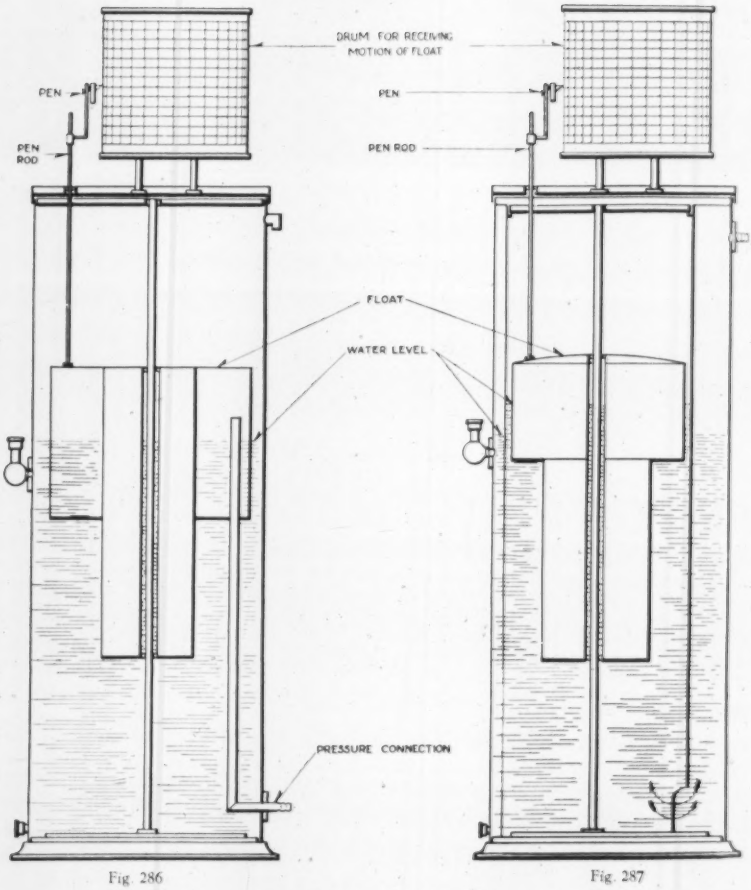


Fig. 286 Fig. 287

INDUSTRIAL LOW-PRESSURE RECORDERS WITH DIRECT-CONNECTED PENS

All cuts on this page, *Bacharach Industrial Instrument Co.*

mounting (Figs. 278 and 281), and full flush front type for panel board mounting (not illustrated). "Permanence of calibration is assured as the mechanism consists of an oil sealed bell so compensated that changes in oil level will not affect the calibration." How this is achieved in the low-pressure unit may be seen in Figs. 278 and 279: the counterweight has the same cross-sectional area as the walls of the bell and is dipped into the oil so that when the beam is once balanced with the pointer on zero, there will be no change in the zero reading due to changes in the level of the oil, or its density, with different temperatures. Minimum range for the full pointer motion of ten inches is 0 to 0.2 in. water; maximum is 0 to 10 in. water. (Pressure or suction.) Fig. 278 shows a mechanism for ranges not exceeding 10 in. water; Fig. 279 shows a three-pointer gage and the visible mechanism is for ranges from −3 to +0.5 in. water.

Mercury sealed bells are used for pressures exceeding 10 in. but not exceeding 25 in. water head or suction. These units operate on the same principle as the oil sealed unit shown in Fig. 278.

The inverted-bell principle can be used for measurement of pressure differentials. In industrial instruments this is preferably accomplished by using two bells. Fig. 281 shows the construction of a representative instrument suitable for any range in differential between 0 to 0.5 and 0 to 10 in. water. The static pressure, however, must not exceed minus 7 in. to 7 in. water.

A pointer travel of 19 inches (300° scale on a seven-inch dial) for 0 to 1 in. water is provided in the *portable* indicator shown in Fig. 282. This instrument stands about 25 inches high and is of quite simple and rugged construction. Maximum range is 4 in. water plus or minus, or 6 in. total (zero center with 3 in. maximum plus and minus).

Inverted-bell recorders are shown in Figs. 283 to 286. Fig. 283 shows a wall type suitable, with water as the liquid, for maximum ranges of 4 in. water. Charts are 4 in. wide and 15 in. long. Fig. 284 shows a floor type for maximum ranges of 20 in. with water. Charts are 6 in. wide and 19 in. long. Fig. 285 shows a mercury instrument of the wall type, for maximum ranges of 15 lb. per sq. in. Charts are 6 in. wide and 19 in. long.

Fig. 286 is self-explanatory, but the designation "float" is wrong: the actuating element is an inverted bell buoyed up by a float.

All vertical edgewise scale instruments (Figs. 276–281) are built in standardized narrow units which may be assembled into multi-pointer gages—as many as twelve in one case. Usually two (sometimes three) quadrant scale units may be combined in one case. There are not, to the best of our knowledge, any horizontal edgewise scale instruments in this inverted-bell class.

As to the inverted-bell recorders, the majority of makes in Europe and here feature strip-charts wound on vertical drums. There are also some round-chart instruments. There are no vertical strip-chart recorders in this category of instruments.

Note how much larger the recorders have to be, in order to compensate for the unavoidable friction effects by the larger effective lift of the bell or float. In this connection it must be remembered that the *area* of the bell or float, multiplied by the differential specific gravity, determines the effective lift. The *depth* of the parts is a design factor depending on the range of the instrument and on the differential specific gravities of the bell material and of the liquid.

In other words, with water or oil the actuating *force* is only a small fraction of that with mercury—areas being equal. This places a limit on the smallness of instruments, but ingenious knife-edges and other friction-minimizing devices make it possible to have small bells actuate *pointers* dependably, since there is no pen friction.

(b) Float U-gages

Though belonging to a different class, as pressure-measuring instruments, some modified U-gages are built so similarly to the inverted-bell gages that they must be considered here.

One was shown in Section 3: the similarity of Fig. 250 to Figs. 278–281 is apparent. As a matter of fact the U-gage units and the inverted-bell units are interchangeably assembled in multi-pointer casings.

Another float type modified U-gage is shown in Fig. 287. The similarity of construction to the inverted-bell instrument shown in Fig. 286 is likewise striking.

(c) Tilting or Balanced Manometers

These instruments comprise a vessel suspended about a knife edge or other frictionless support, and containing a body of liquid with two surfaces—just like a U-gage. When the pressures on both surfaces are equal, the vessel hangs vertically and its pointer reads zero. Under the application of a differential, the body of liquid is displaced, shifting the center of gravity and causing the container to incline. An instrument of this type which has won wide acceptance in America is the Cochrane tilting manometer. It is used almost exclusively for flow metering. The "ring" manometer, a German instrument, deserves mention as also having been made practical. These two and other balanced manometers are hardly ever used to measure absolute pressure or gage pressure, being specially adapted for differentials. They will be described under flow meters.

CORRECTIONS—"Isotropic" should be "isentropic" in the definition of Total Pressure, Chapter X, Section 2, page 733 of December issue. In the last column of Table VIII (page 736, December) the minus exponents should be plus, and the decimal shifted in the eleventh line, making the value of 1 gram/sq. cm. = 735.56 microns Hg.

Again we find it impracticable to run one full chapter of Mr. Béhar's Handbook in one single issue. This most interesting chapter on Pressure Measuring Instruments will be concluded in the March issue. The titles of remaining sections are listed on page 55. This Chapter will be followed by one on instruments for the automatic control of pressure, scheduled originally for March, now scheduled for April. See also announcement on page 12. —*The Editor.*

Balances, Scales and Weights†

*Arthur Schroder**

THE *Assay Balance* is essentially an analytical balance, coming between the regular analytical balance and the micro-analytical balance in capacity and sensitivity. The beam is usually very short, 4 to 5 inches long and the pans only 1 to 1½ inches in diameter. The pan stirrups are usually suspended from the end of a single wire attached to the stirrup support. There are in general two types of assay balance—the one is similar to the analytical balance, with the above exceptions, while in the inverted type, the indicator arm is above the balance beam, its weight counterbalancing some of the weight of the pans and so reducing the inertia of the moving parts and making for greater sensitivity. The capacity is usually about 5 g. with a sensitivity of 1/400 to 1/100 mg. Some of the larger sizes with a capacity of about 25 g. and sensitivity of about 1/40 mg. are almost within the range of the analytical balance, although of the assay type of design. (See Fig. 16)

The term *Bullion Balance* like the term Assay balance, has no particular meaning of its own. The purpose is of course, the weighing of bullion and specie in one form or another but the capacity and sensitivity of the balance put out by different manufacturers vary quite widely. Generally speaking, the bullion balance has a greater capacity than the analytical balance and is characterized by its extremely heavy construction and exceptional sensitivity, 1 grain under a full load of 3000 oz. As a rule these balances are not enclosed in cases and do not have a graduated beam, but otherwise are quite similar to the analytical balance in design. (See also gold coin balances and silver and specie scales.)

The *Bates Sugar Balance* (*Becker*) as designed by Dr. Frederick Bates of the U. S. Bureau of Standards is a 200 g. analytical balance, with ungraduated beam, sensitivity 0.1 mg. with the bows of the regular balance replaced by a single half-bow at the rear of each pan, to facilitate adding or withdrawing portions of the sample of sugar during analysis.

Counting, Calculating and Estimating Scales and Balances—In establishing production costs, transportation charges, scrap material recoveries, etc. industries in which large numbers of standardized articles are produced, have demanded an instrument whereby the gross weight of a number of articles can be rapidly determined from the weight of one—or the weight of a large volume of liquid from the weight of a sample, and conversely, knowing the weight of a large number of smaller articles, to establish the weight per article, or the number of articles per unit weight. To meet this demand a large number of counting and estimating scales and balances have been developed. Thus in the *Seko estimator* (*Seederer-Kohlbusch, Inc.*) Fig. 19, the weight of a gross, hundred or thousand can be read directly from the beam after the sample or single article has been counterpoised.

†Continuation of Chapter I of Handbook of Laboratory Instruments and Apparatus.
*Technical Director, Fisher Scientific Company.

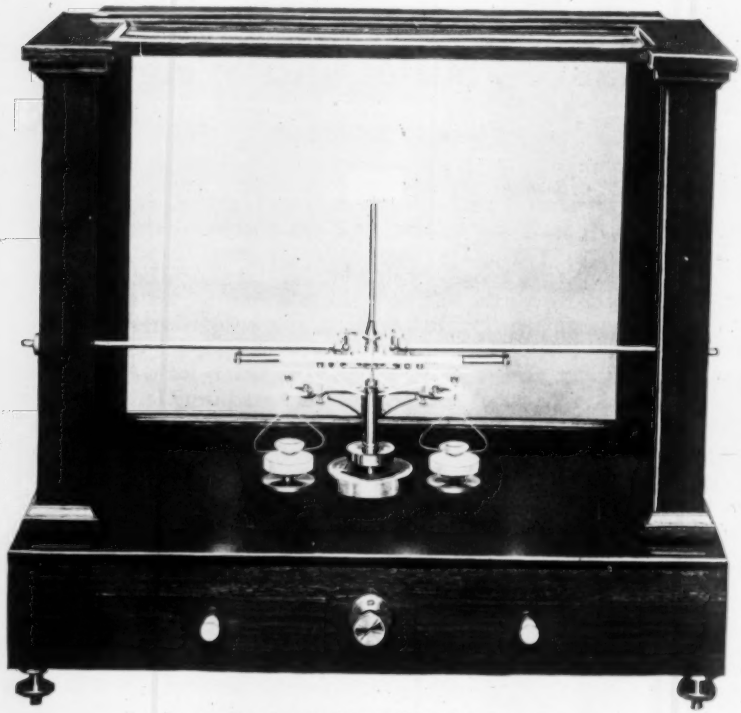


Fig. 16. Assay Balance (*Henry Troemner*)

The weight of the sample can be read on the upper graduated scale, each graduation corresponding to 1/100 oz. while the weight per hundred, per gross and per thousand in lbs. and oz. can be obtained on parallel graduate scales on the same beam. The range is 1 lb. sensitive to 1/1000 oz. In the Seko decimal weigher the weight or number of articles can be directly obtained, but here the beams are calibrated in terms of the decimal system, the range being up to 1 lb. in 1/10,000 lb. or 500 g. in 50 mg. subdivisions. For counting, the Seko counter has 2 pans, any weight placed in one, counterbalancing a weight 10 times as great (or visa versa) in the other. Thus counting a certain number of units into the smaller pan, and pouring the articles into the larger pan until equilibrium is reached, the number in the large pan will be 10 times as great as the number in the smaller pan. In the same manner counting on the basis of a dozen instead of ten is similarly accomplished. The capacity is 4 lbs. sensitive to 1/1000 oz.

The torsion estimating scale is the regular box type torsion scale with the upper beam graduated to 16 oz. in $\frac{1}{8}$ oz. subdivisions while the lower is graduated 0 to 160 oz. in 16 oz. per gross divisions. This same scale is obtainable, calibrated on the basis of 100 instead of the gross.

Similar counting and estimating scales are available in the torsion type, for use in the textile industry. The woolen cloth and duck scale indicates the weight of a square or running yard of cloth of any width when a sample is counterpoised. The cotton cloth scale gives the number of yards of

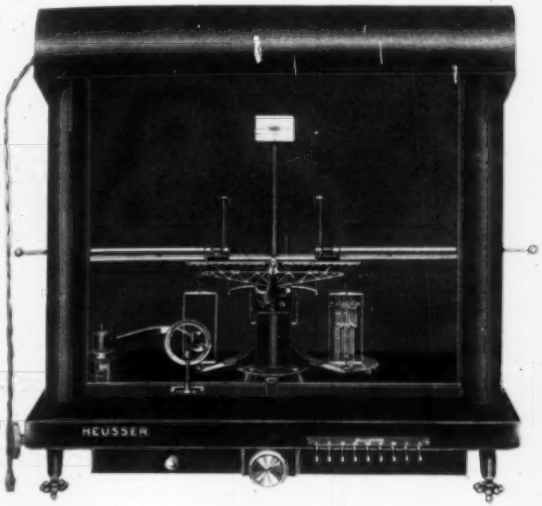


Fig. 17. Assay Balance (*Mine & Smelter Supply Co.*) with multiple weight attachment, mechanical pan extractor, and electrical illuminator. This balance has a sensitivity of 1.500 mg. and a period of oscillation of 7 seconds.

cloth per lb.; the cotton yarn scale gives the "yarn" number; while other scales give similar information for silk, braid, hosiery, underwear, grain, seed, paint, etc.

Centrifuge Tube Balances are small simple equal arm balances with metal cup-shaped pans for holding the centrifuge tubes while they are being brought to the same weight before insertion into the centrifuge. Ordinarily the tubes, tubes holders and contents are of somewhat different weights, which while not very large are nevertheless still great enough to throw the centrifuge out of balance. In use the tube holder and the tube plus contents are placed in the "pan" and water or other liquid added to the lighter weight tube until the weights are equal. The balances are obtainable in 2 sizes, to take the 15 and 50 cc. tubes used in clinical diagnosis, and general analysis.

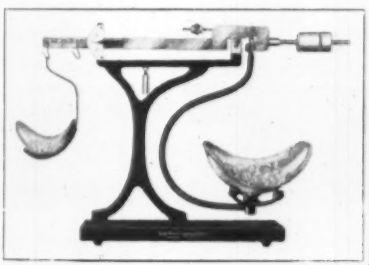


Fig. 18 Seko Counter

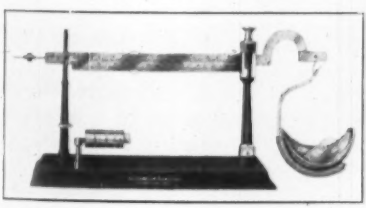


Fig. 19 Seko Estimator

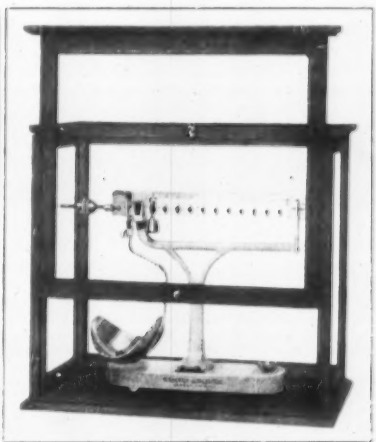


Fig. 20 Seko Decimal Weighet

Diamond Balances—There is no diamond balance as such. The so called diamond balances are in reality analytical balances of one sort or another, but derive their name from the fact that they are used for the weighing of diamonds and have the beam calibrated in terms of the metric carat (200 g.)

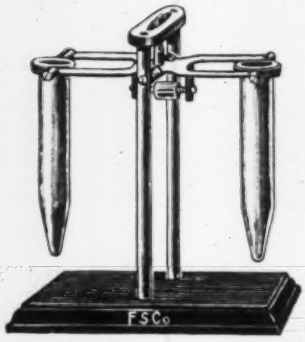


Fig. 21. Centrifuge Tube Balance (*Fisher Scientific Co.*)

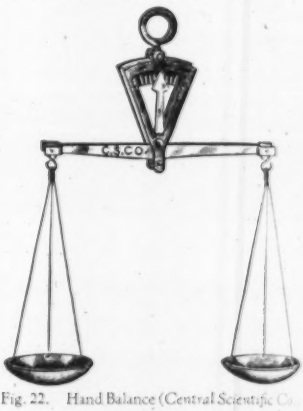


Fig. 22. Hand Balance (*Central Scientific Co.*)

Thus we have the Chainomatic Diamond balance which is the Chainomatic analytical balance with its column calibrated in terms of 1 carat in 0.01 divisions and a capacity equal to 750 carats

The Pearl Balance is similar to the above but has its scale calibrated in terms of 4/100 pearl grains.

Dispensing Balances are similar to prescription balances and scales, but of a greater capacity and somewhat lesser sensitivity.

The *Geological Torsion Balance* has of late come to the front as a field laboratory instrument. The Eötvös Balance measures the very minute changes of gravity which may be positive, that is, increases, caused by the presence of heavier deposits, or negative deficiencies caused by lighter deposits taking the place of heavier beds. In case of exploration for oil, the instrument is used indirectly, that is, not to locate oil deposits, which it is unable to do, but to locate oil structures favoring accumulation of oil in commercial quantities. In principle, it can be used with equal success for any type of oil structure, that is, salt domes, faults, anticlines, and intrusions. The greatest successes, however, have been obtained so far in the search for oil structures of salt dome type.

The instrument is limited by the necessity of presence of density difference between the beds, or structure looked for, and that of the overlaying strata. These differences do not need to be large, the instrument being sensitive to a degree not believable to the layman. This sensitiveness, unfortunately, represents an added limitation, that is, the desirability of a flat, or nearly flat surface, all hills and valleys having an effect on the instrument. This effect can and is being calculated at every station occupied, but this compensation system has its limitations.

The instrument itself is a modification of the Cavendish Torsion Balance. The Cavendish instrument consists of a fine wire on which a horizontal beam is suspended, which beam carries 2 weights, masses, on its 2 ends. A torsion balance of this form will give information only about the deviation of the actual form of the earth's sphere, at a point, from an ideal form, called level surface, which theoretical information does not always have a

practical, useful meaning. Eötvös modified this instrument in such a way that the 2 masses are not placed in the same horizontal level.

The actual use of an original Eötvös Torsion Balance may be described briefly as follows: The instrument is set up at certain intervals, which is anywhere from 200 feet to 2 miles, according to the purpose and opinion of the users. A small portable insulated house is provided to protect the instrument from temperature, wind, etc. The instrument is placed in its first position usually magnetic North, suspended systems released, and the instrument left alone. After 50 minutes, which is the time necessary for the beams to come to rest plus a safety period, the observer enters the house, flashes light on the scale, notes the positions, temperatures, turns the instrument 120°. The same procedure is followed once more, which completes 1 set of readings. It is usual, however, to read in 2 more positions, at least, that is, 5 readings all told.

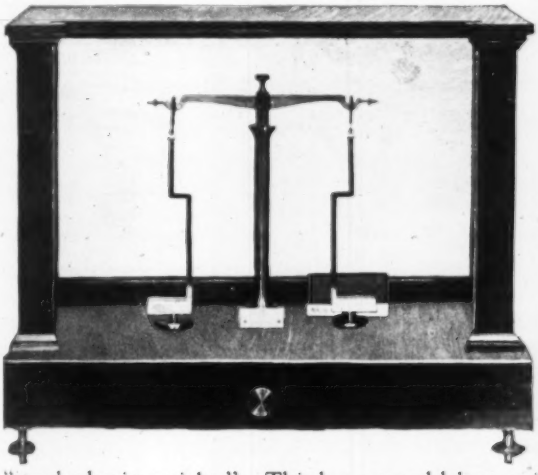


Fig. 23. Gold Coil Balance (Henry Troemner).

The *Gold Coin Balances* are merely adaptations of other balances and scales to a particular purpose. The Troemner gold coin balance, Fig. 23, again of the analytical balance type has flat "offset" scale pans on which the coin is placed and counter balanced against a "least current" or "standard coin weight." This has a novel labor saving device in that the pans have inserted steel plates for carrying the coins and weights to prevent their undue wear. These plates have slots into which pan arrests are moved to prevent oscillation of the pans during loading. A trapdoor behind the coin pan covers a chute through which the coins can be pushed from the pan directly into a receptacle at the back of the balance. Some of the gold balances have the beams calibrated in grains for indicating how much a given coin is lighter than the standard.

Hand Balance—The oldest type of weighing balance known. The 2 pans are merely hung from a metal beam with metal knife edges and planes, the pans usually are of horn or celluloid. Due to the very light weight material used in the construction, these balances are remarkably sensitive. Several sizes and capacities are available, the 150 and 300 g. capacities finding much popularity as a means of introducing students in the high schools to rudiments of the science of weighing. In its more elaborate forms it is known as the portable prescription scale of the itinerant doctor and when enclosed in a case as the pocket balance. While quite sensitive this type of balance is very seldom used in industry, because of its inconvenience.

Hydrostatic Balances derive their name from the fact that they can be used with a reservoir of water placed between the stirrups for specific

gravity determinations and similar tests where the material to be weighed is immersed in a liquid and supported from one of the balance arms. The balance is characterized by the very wide stirrups, pans attached permanently

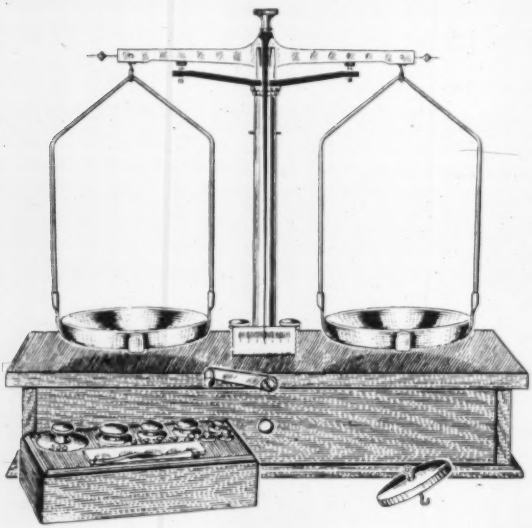


Fig. 24. Hydrostatic Balance (Fisher Scientific Co.)

to the stirrups as in dispensing scales and balances, and the extra hook on the lower side of the stirrup support for the attaching of the wire or string for supporting the material to be weighed in the liquid. Many of this type of balance have an auxiliary platform which can be swung over the one pan and between the stirrup for supporting the liquid container. The term "hydrostatic" as applied to balances is falling into disuse because many balances now called hydrostatic, while they look somewhat like a hydro-static in general appearance lack some of the essential features. Today the term is applied to almost any balance with wide stirrups, attached pans, ungraduated beam and a fair sensitivity. The range of this type of balance is 100 to 1000 g. with a sensitivity of about 1 mg. Abroad the term hydrostatic is often applied to scales with wide pans permanently attached and usually classed here as the druggist counter or dispensing scale. Capacities of such scales are larger than those of the more truly hydrostatic balance. Cases while obtainable for practically all sizes of this balance are not the rule. While this type enjoyed much popularity in years gone by, it is rapidly being replaced by more accurate and more sensitive dispensing, the specific gravity and the analytical balances.

Fig. 25. Harvard Trip Balance (Fisher Scientific Co.)

The Harvard Trip Balance while called a balance is a scale of 2 kg. capacity, sensitive to 1/10 gm., with steel knife edges riding in agate V-shaped bearing plates. Pans are flat with glass or porcelain tops. The beam is calibrated to 10 g. in 1/10 g. divisions. The characteristic features of this scale are the extra hooks within the base and attached to the pan supports. From these objects can be suspended into water for specific gravity determinations, when the scale is supported above the table top by a rod and C-clamp. (Fig. 25) This makes a handy tool for the general science, elementary chemistry and physics school laboratories where rugged construction and moderate accuracy are paramount.

The *Jewelers Balance* is similar to the hydrostatic balance but usually has a somewhat greater capacity (up to 50 or 100 oz.)

The Jolly Balance—One of the oldest, simplest yet frequently used balances of moderate accuracy is the Jolly balance. In its more improved form, it has an elevating, telescoping arm to which is attached the one end of the extension spring which has its other end kept within closely defined limits by a calibrated glass tube through which the weighted end of the spring moves. The extension or pull on the spring is determined by the motion of the upper end and is indicated on the graduated telescoping arm with its vernier. The balance is normally supplied with a light spring, extending 500 mm., the total length of the arm for an added load of 10 g. giving a sensitivity of about 2 mg. The balances are used for the determination of specific gravity, surface tension, torsional stress, period of vibration under varying load, etc.

Magnetic Susceptibility Balance—As the temperature of a ferro-magnetic material is increased from room temperature, the magnetic susceptibility changes until a point is reached at which the material is practically without any magnetic susceptibility. This point is called the magnetic critical temperature. For iron it is about 790°C., for cobalt 1150° and nickel about 360°C. In studying this property of monel metal, E. T. Post developed a modification of the chainomatic balance (see above) and auxilliary apparatus, which offers promise of much utility for the study of magnetic susceptibility. He uses a chainomatic balance, slightly modified, and suspends from one pan, by means of a thin wire, the specimen to be investigated. This hangs in the magnetic field of an electromagnet, the attraction of which is measured by increasing the load on the other pan of the balance by lowering the chain. The specimen was heated by an electric furnace surrounding the specimen. For details of construction, the original description* should be consulted.

Multiple Beam Balances are similar to the regular specific gravity balances in form, and have a long calibrated arm and a shorter pan-supporting arm. The longer arm may carry two, three or more calibrated beams, (the double beam, triple beam balance, etc) in either the same horizontal or vertical plane. The weights used on the beams bear a decimal relationship to one another. These balances are usually supplied with auxiliary adjustable shelves for supporting the liquid containers for the specific gravity determinations.

Percentage Weight or Cement Scale.—This scale is similar to the ordinary scale but carries a beam calibrated in both fractions of a lb. and in percentages of a lb. Its particular use is the weighing of batches of cement before and after drying, for the moisture content test. With the scoop on the left side the weighing is as usual, the weight indicated on the beam.

*Instruments, Vol. 3, Nov. 1930, page 681.

Using a 1 lb. sample, in the scoop on the left side, and then subjecting the sample to some chemical reaction, the percentage increase can be obtained from the beam reading. In the moisture determination the sample of 1 lb. is first weighed as usual, and then after being dried, is placed in the scoop on the right side and the percentage loss in weight obtained by balancing and reading the beam. A counterpoise is of course necessary for the weight of the scoop. The capacity of the scale is 4 lbs. with the extra weights. Where 2 or 3 lbs. or proportionally larger samples are employed, the reading on the percentage scale are respectively ½, ⅓ etc. of the indicated percentage.

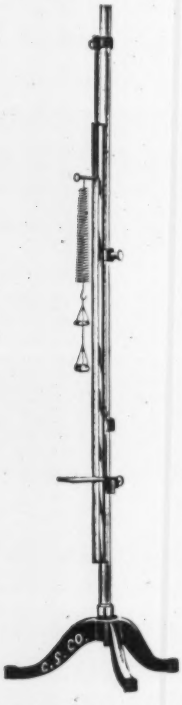


Fig. 26. Jolly Balance (*Central Scientific Co.*)

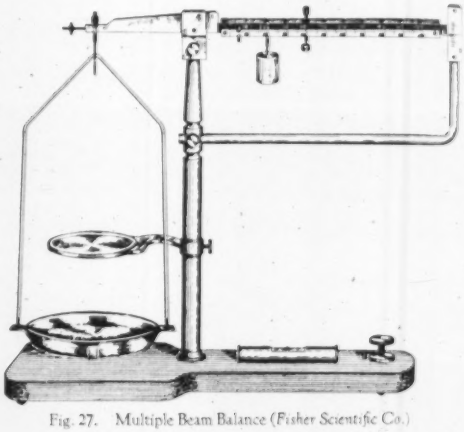


Fig. 27. Multiple Beam Balance (*Fisher Scientific Co.*)

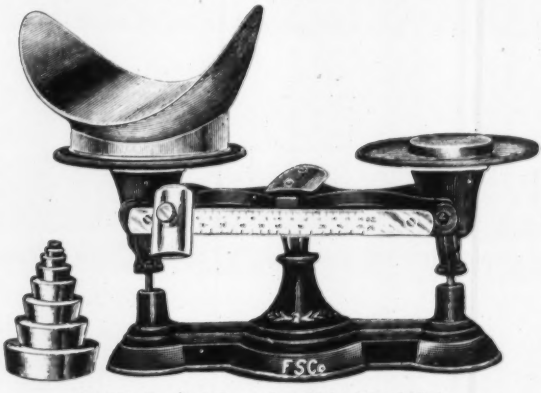


Fig. 28. Percent or Cement Scale (*Fisher Scientific Co.*)

Percentage Composition of Solder Scales, see Solder Test Scales.

Paper Basis Weight Scale (Thwing)—In the control of paper the weight of the pulp in the sheets and the amount of moisture contained are the basis of sale. The Thwing Instrument Co. has produced a highly refined basis weight scale (Fig. 29) whereby the weight of a ream of paper can be obtained from the weight of a single sheet. The scale is direct reading and comes in a number of ranges; the standard ranges are 0-25 and 0-50 lbs.; the multiple range scales are equipped with standard dials and calibrated for full limit of dial range for either the 480 or 500 sheet ream, and up to 100 or 200 lbs.

Additional special dials and calibrations can also be obtained. In use the scale is mounted on a wall, preferably suitably protected from interferring drafts, and leveled. When dial starts at zero, scale should come to equilibrium at zero, while for the limited range dials equilibrium will be established by adding a known weight to the left end of the beam and the scale will indicate the corresponding value. Thus with a dial starting at 20 and a 20 weight on the left side of the beam, the scale will read 20. At least one calibration weight is supplied with each scale. When the scale is designed for both 480 and 500 sheets per ream, the change from the 480 basis to the 500 basis is made by adding a small additional weight to the

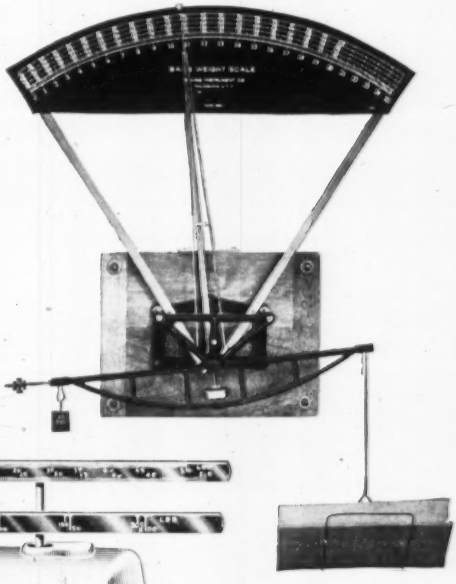


Fig. 29. Basis Weight Scale (*Thwing Instrument Co.*)

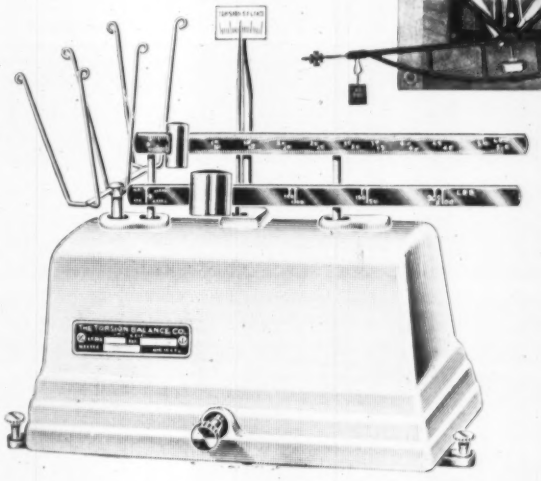


Fig. 30. Torsion Paper Scale (*Torsion Balance Co.*)

beam. For the multiple range instruments additional weights are used for converting to the desired range. Test weights and additional weights are then so indicated, and 2 or more sets are necessary. The scales all have cast bronze truss beams, sapphire bearings and steel pivots and 20″ pointers. They are dead beat for quickly coming to rest during use. An adjustable index pointer on the edge of the dial facilitates rapid checking of the scale at all times. In addition to its use in weight determination the scale can be used for moisture determinations. Special scales and dials are available for special uses, such as sheets per bundle, pounds per bundle, ounces per square foot, etc. A modified form of the scale is the differential scale in which another paper holding frame is attached to the left side of the beam and the

difference in the 2 loads is indicated on the beam. This type is used for checking the difference in weight due to sizing, wax and similar coatings as referred to the untreated paper.

Differential Scales (Thwing Instrument Co.)—These scales are similar to the Thwing basis weight scales, but have 2 sample holders, one attached to each arm of the beam. They are used to indicate the difference in weight between a coated and an uncoated sheet of paper, and are particularly useful in studying the weights of sizings, gums, and other coatings and treatments as affecting the paper. The scales come in 2 sizes, range 0 to 25 lbs., graduated in 1/10 lb. divisions, and 0 to 50 lbs., in 2/10 divisions.

The *Paper Scale* of the Torsion Balance Co. (Fig. 30) indicates directly the weight per ream of 480 or 500 sheets when one sheet is placed in the wire holder. The scales comes in sizes 0 to 20, 0 to 50 and 0 to 250 per ream with corresponding sensitivities.

Prescription or Drug Scales and Balances while the term prescription balances (or scales) has been restricted in the past to mean those balances used in drug stores and pharmaceutical laboratories, and were usually calibrated in terms of the apothecaries units of weight, the gradual introduction of the metric system of weights and the gradual extension of the use of this type of weighing device to other industries has left the term with little real significance. What is a prescription scale in one manufacturer's catalogue may be a hydrostatic balance or a portable assay balance in another. In general the term seems best applied to such balances as are graduated in terms of apothecaries units and of limited capacity—about 4 drachms, while the term prescription scales might well be limited to those scales graduated up to about 1 lb. (apothecaries). One outstanding feature is the enclosure of the dispensing scale in a box or case to protect the parts from dust and drafts. Other scales also have this feature, while the prescription scale is characterized by always having the lever system entirely enclosed in a box of glass or wood, with the pans left exposed. In the newer types, an additional cover is fitted over the pans. Seldom if ever, is the beam of the dispensing balance graduated as in the analytical balance.

In some states these balances and scales are clearly defined as to type and sensitivity and their usages prescribed by law. This should be borne in mind when purchasing them. The Bureaus of Weight and Measures or the Bureaus of Standards of the various states, will gladly supply information on this subject to anyone interested.

The capacity of a prescription balance is usually 4 drachms with a sensibility reciprocal of from 1/100 to 5/10 g. The capacity of the prescription scale is usually 16 oz. with a sensibility reciprocal of from 1 to 5 grams. Balances graduated in terms of the metric equivalent are also available. Practically each size can be duplicated in the torsion style.

Pulp Balances—These balances are similar to the hydrostatic balances but differ from them in that they usually have removable pans and are not as a rule equipped with the extra hook on the stirrup support. These come in a number of sizes from 100 to 1000 g. with a sensitivity of from about 1 to 5 mgs. The larger sizes are frequently referred to as *bulk* balances and have steel rather than agate knife edges. The main use is the weighing of large samples of pulp for the moisture determination and general large sample weighing where an accuracy of about one part in 10 to 100 thousand parts is required. While not generally supplied with cases they are obtainable with cases. They are sometimes called Mohr's balances.

Quadrant Scales (Amthor Testing Instrument Co.)—The quadrant type scale (Fig. 33) is of the simple lever type, with the indicator arm moving across a graduated scale, the shape of wh ch is a quadrant of a circle. This type of scale is direct reading, frequer.tly with a number of auxilliary calibrations. When the specimen is placed on the pan or in the scoop, the weight is instantly indicated on the indicator scale. There are no dials or mechanical devices which might affect the weighings, so the scale is remarkably free from error from such sources. The scales are calibrated in a wide variety of units such as paper basic weight, ream weight, gross weight, area weight of paper, yardage of twine, etc. Special calibrations are also available to order.

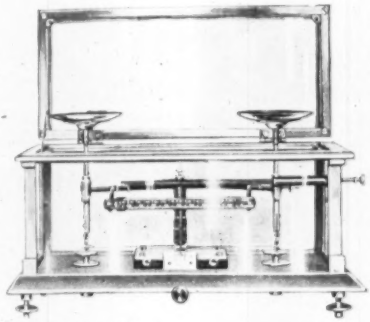


Fig. 31. Prescription Scale (*Henry Troemner*)

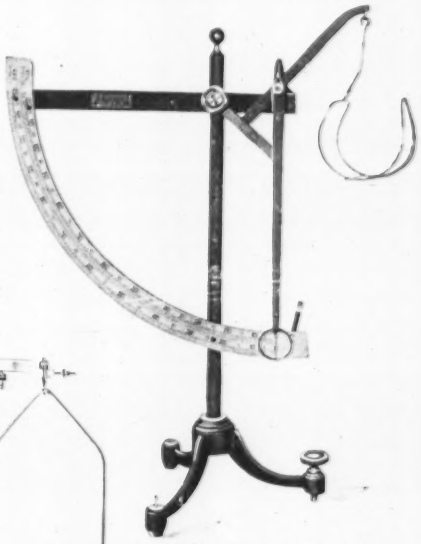


Fig. 33. Quadrant Type Scale (*Amthor Testing Instruments*)

Fig. 32. Pulp Balance. (*Seedever-Kohlbush Co. Inc.*)

The *Full Sheet Paper Quadrant Scale* is used almost exclusively for testing paper products for weight. The scale is subdivided into 3 separate rows of graduations corresponding to 480, 500 and 1000 sheet reams of paper. When one full sheet is placed in the scoop, the weight of the entire ream of the desired number of sheets is directly indicated on the quadrant. This scale can also be used for weighing board. When one square foot of board is placed in the clamp the indicator shows the weight per 1000 square feet.

The *Reduction Sheet Paper Scale* is similar to the full sheet scale but can be used when only small samples of paper are available for test. With the scales are furnished dies or cutting plates used for cutting the given sample into pieces of known area equal to 1/100th that of a full sheet. The cali-

bration is such that the full weight of a ream of 480 or 500 sheets is then indicated on the quadrant.

The *Robervahl Balance* is similar to the Harvard Trip scale but has a longer curved beam and dished pans. It does not have the hooks in the base nor the support rod. This type is supplied in capacities up to 10 lbs., with and without calibrated beam. (Fig. 34.)

Tissue and Waxed Paper Scale is similar to the above quadrant scales, but is calibrated for the basis weight of tissue and waxed papers. It has an auxiliary weight to be used for increasing the range to twice its normal range. It is extremely accurate, reading to $\frac{1}{8}$ lb.

Board Scales are similar to the above, but have the quadrants calibrated for the direct weight of a sample and also the number of such sheets to a 50 lb. bundle. This scale is obtainable with either or both calibrations as desired.

The *Cordage or Twine Scale* also indicates the yardage or the number of feet of cord or twine per lb. based on a one foot length of sample.

All the above quadrant scales are obtainable in pocket sizes.

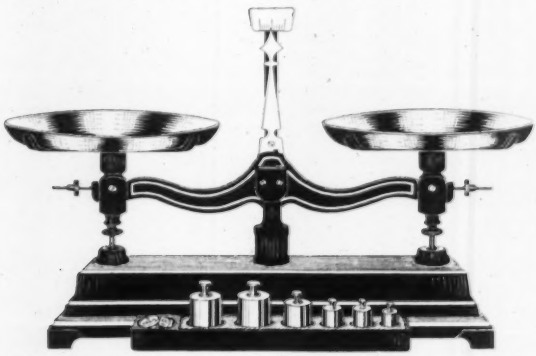


Fig. 34. Robervahl Balance (*Fisher Scientific Co.*)

Fig. 35. Scalers Precision Balance (*W. & L. E. Gurley*)

Foil Scales, also of the quadrant type are designed for the testing of aluminum, tin or composition foils for the covering area or yield, cutting plates or dies are furnished for cutting the sample to a definite area. When the sample is placed on the hook, the yield of the foil, in square inches per lb. is indicated directly on the quadrant.

One balance of the larger size which deserves particular mention is the *Sealers Precision Balance** (*W. & L. E. Gurley*) which is sensitive to one part in 500,000 or 60 mg. with a 25 kg. load. All bearing plates are agate with hardened steel knife edges. Special provision has been made for adjusting knife edges so that they are parallel and in the same plane. By means of the adjusting weights on the beam the center of gravity can be raised or lowered to alter sensitivity as desired. Horizontal counterpoises afford ready readjustments in the zero point setting. The indicator moves inside the base of the beam across a scale with a mirror background. This balance is equipped with beam arrest and pan arrest similar to those employed in the analytical balance. (Fig. 35).

The *Silk Skein Balance* is an analytical balance of 500 g. capacity, sensitivity 10 mg. with ungraduated beam and with the right hand pan replaced by a trough-like pan. It is used for weighing silk and similar material during the moisture determination.

The *Silver Scales* are merely a heavy capacity pan type scale with a range up to 100 oz. with a sensitivity of about 0.01 oz. The smaller scales with a capacity of about 12 oz. are frequently referred to as *Jewelers Scales*. The large sizes capacity 400 to 1600 oz. are used for weighing coins in bags, where one bag is balanced against another, merely as a preliminary check when coins are shipped from one laboratory or bank to another.

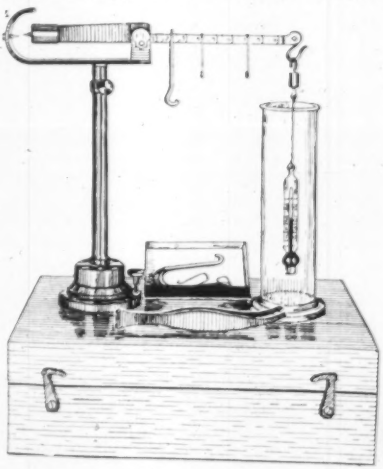


Fig. 36. Westphal Specific Gravity Balance.

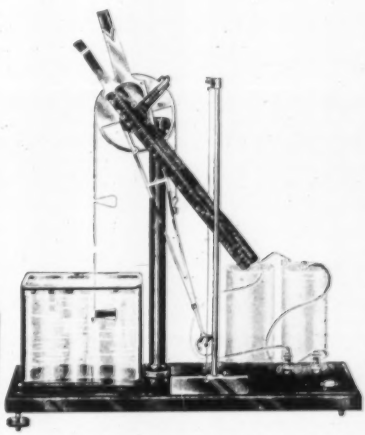


Fig. 37. Gravitometer (*Eimer and Amend Co.*)

Specific Gravity Balance—The specific gravity of a liquid can be readily determined on the *Westphal Balance*. This labor saving tool has undergone many changes in detail, but it still retains its original form with a long beam arm calibrated directly in terms of specific gravity and counterpoised with a short arm which carries the bob or plummet. In use the plummet is

*For laws covering the use of Sealer's Weights and Measures, see U. S. Bureau of Standards, Handbook No. 11.

balanced in air by means of the movable weight immediately above it and by means of the leveling screws in the balance base. The plummet is then immersed in the liquid, the specific gravity of which is to be determined, and equilibrium again established this time by moving the weights on the calibrated beam. Gravities can be read directly to the 3rd and in some cases to the 4th decimal place. Some of the balances are equipped with *thermo-plummets*, or plummets within which is a thermometer for indicating the liquid temperature, and also with extra unit weights for increasing the range up to a specific gravity of 4 instead of the usual gravity of 2. It should be noted that as the operations of these balances depend on the buoyant effect of the liquid on the bob, they must be calibrated for the weight and displacement volume of the bob. Bobs to be interchangeable must therefore all be of the same volume displacement and of the same weight. Those supplied by one manufacturer do not necessarily give correct readings when used with balances made by another manufacturer.

The specific gravities of liquids can also be determined by means of the modified chainomatic balance. In construction this balance is similar to the analytical chainomatic, but has the standard pan replaced by a plummet (Fig. 38). The plummet displaces exactly 2 g. of distilled water at 20°C.

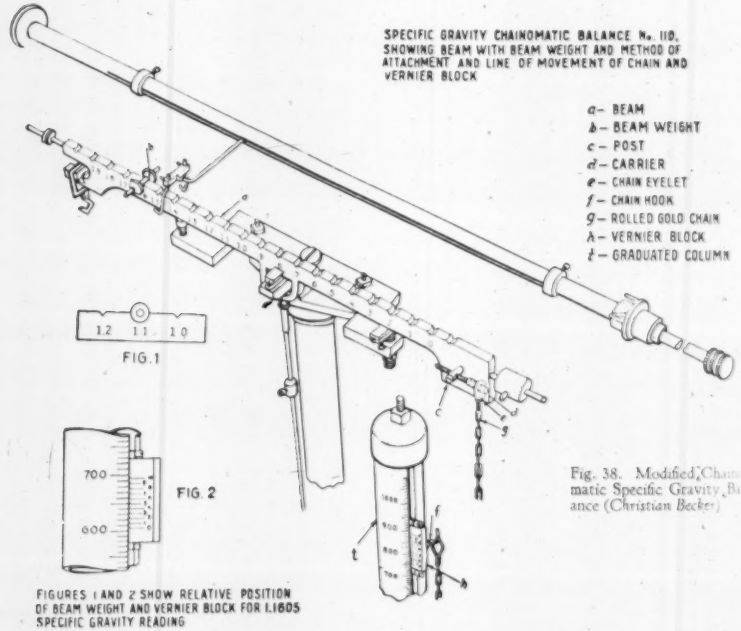

SPECIFIC GRAVITY CHAINOMATIC BALANCE No. 110, SHOWING BEAM WITH BEAM WEIGHT AND METHOD OF ATTACHMENT AND LINE OF MOVEMENT OF CHAIN AND VERNIER BLOCK
a– BEAM
b– BEAM WEIGHT
c– POST
d– CARRIER
e– CHAIN EYELET
f– CHAIN HOOK
g– ROLLED GOLD CHAIN
h– VERNIER BLOCK
t– GRADUATED COLUMN
12 11 10
FIG. 1
700
600
FIG. 2
FIGURES 1 AND 2 SHOW RELATIVE POSITION OF BEAM WEIGHT AND VERNIER BLOCK FOR 1.1805 SPECIFIC GRAVITY READING

Fig. 38. Modified Chainomatic Specific Gravity Balance (*Christian Becker*)

(or 15°C. if so specified) so only small quantities of liquid need be available for a test. Broken plummets can be replaced. Balance is direct reading in specific gravity to 4th decimal place, for all gravities up to 2.0000 in the one model and up to 4.0000 in the other.

A modified torsion balance (Fig. 39) is particularly well suited for determining the specific gravity of liquids, particularly the more viscous like varnish, condensed milk, tomato pulp and glue. The bottle holds exactly 100 ml. at 15°C. (or 20°C. if specified) and has a capillary hole for

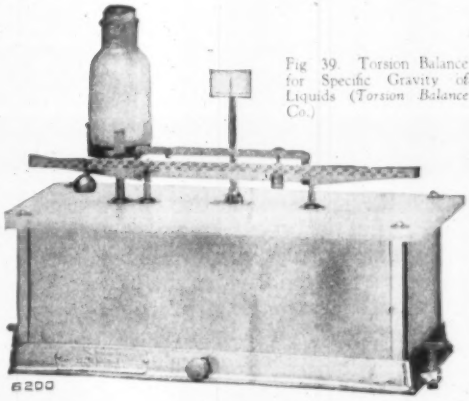


Fig. 39. Torsion Balance for Specific Gravity of Liquids (*Torsion Balance Co.*)

exactly establishing the volume. A depression in the stopper allows for expansion of liquid due to any temperature increase. In use the filled bottle is placed in the holder and equilibrium of the balance established by moving the slide weights. The beams are calibrated to read directly in terms of specific gravity and cover a range of 0.7000 to 1.4000.

Gravitometer, specific gravity balance (Eimer & Amend) (Fig. 37). This is somewhat similar to the other specific gravity balances but differs in that it is used to determine the specific gravity of a solid immersed in water and no additional weights are required. The sample is weighed in air (in the upper hook) and the beam permitted to come to rest while the buzzer is operated to vibrate the balance and overcome friction. The graduated scale arm is then rotated until it is on center line with the beam. This establishes the angle of inclination of the reading scale. The sample is then transferred to the lower hook and weighed in water. The beam is permitted to come to rest and the intersection of the vertical wire (mounted on the vertical rod and moving in the slot in the base) is read through the reading mirror. This balance is recommended for control tests in rubber laboratories and similar work where gravities up to about 4.4 and moderate accuracy are involved.

For determining the specific gravity of a gas the Edwards *Gas Density Balance* (*Refinery Supply Co.*) serves admirably. The operation of the balance is based upon the laws of compressibility and buoyancy of gases. It is described in the U. S. Bureau of Standards, Technologic Paper 89, as follows:—

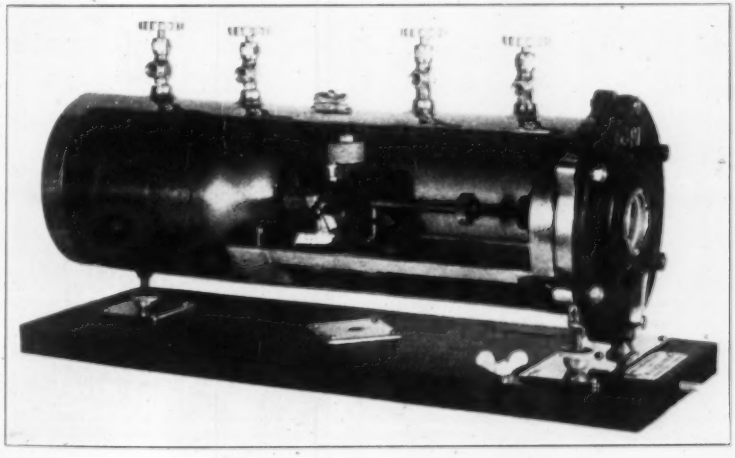


Fig. 40. Gas Specific Gravity Balance (*Refinery Supply Co.*)

According to Boyle's law the density of a gas is proportional to its pressure; and the buoyant force exerted upon a body suspended in a gas is proportional to the density of the gas and therefore to its pressure. Therefore, if the buoyant force exerted upon a body is made the same when suspended successively in two gases, then the densities must be the same at these pressures; or the densities of the two gases at normal pressure are inverse ratio to the pressures when of equal buoyant force.

The Ac-Me specific gravity balance consists of a balance beam carrying a sealed float on one end and an adjustable counter-balancing weight on the other end. This balance beam is suspended by means of two crossed phosphor bronze strips on each side. The crossed suspension permits the beam to have free movement about the point of oscillation but prevents the lateral motion of the beam. The end of the balance beam is equipped with a millimeter scale which is used in connection with a hair-line indicator to show when the beam is in balance. The container of the balance is provided with an ample number of valve connections to take care of the various hook-ups necessary in making a balance test. The connections on each end are provided with purging rings which aid the thorough purging of the instrument and prevent the deposit of any moisture on the internal mechanism of the balance.

The specific gravity of a gas referred to air as unity may be represented as the ratio of the absolute pressure required for balancing the beam in air to the absolute pressure required for balancing the beam in the gas, expressed as a formula:

$$\text{Sp. Gr.} = \frac{A}{G}$$

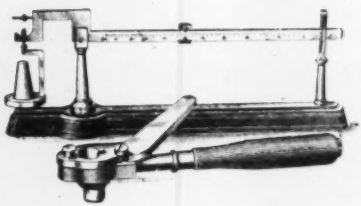


Fig. 41. Solder Test Scales (*Seederer-Kohlbush, Inc.*)

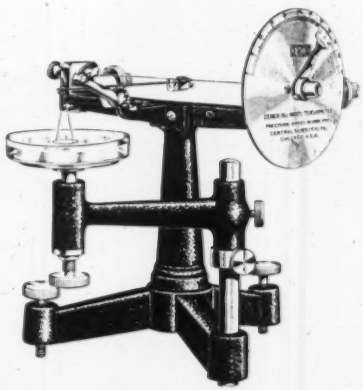


Fig. 42. du Nouy Tensimeter (*Central Scientific Co.*)

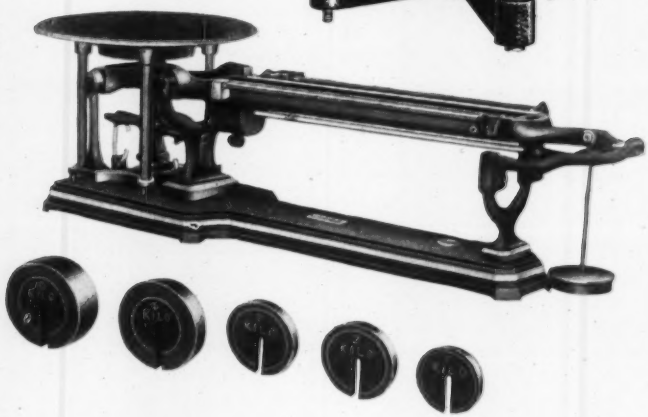


Fig. 43. Metric Solution Scale (*Henry Troemner*)

where A = the manometer pressure plus (algebraically) the barometric pressure, while the beam is balancing in air. G = the manometer pressure plus (algebraically) the barometric pressure, while the beam is balancing in gas.

Specie Scales are similar to the Silver Scales but have an additional calibrated beam from which the shortage in dollars, of a load of gold can be read directly from the beam.

Solder Test Scales. For the determination of the percentage composition of tin-lead alloys a special scale has been developed. To make a test it is only necessary to fill a cast mold with the alloy and when cool, to place on scale pan and balance with the sliding weight on the beam. Results are direct in percentage of tin with an accuracy of about 0.3%.

The *Metric Solution Scale (Troemner)* is a compound lever type scale (Fig. 43) with the long arm carrying 2 graduated beams and a rod. One beam is graduated to 1 kg. in 100 g. divisions, the other 100 g. in 1 g. divisions, while the rod carries a sliding weight for taring any containers placed on the scale's platform. The capacity, including the additional weight is 20 kg. sensitivity 1 g. When furnished with a large metal box or cage on the scale platform this is known as the *Animal Scale*, while when equipped with a basket or scoop it is referred to as the *Baby Scale*. When the rod is replaced by a plate, perforated by a series of holes into which counterpoise iron balls can be put, the scale is known as the *Ball Solution Scale*. The balls serve the same purpose as the additional weights supplied on the standard type. Six holes are standard. A ball in the hole nearest the platform counterpoises a 1 kg. load on the platform. A ball in the next hole counterpoises 2 kg., etc. This type is also obtainable in several other capacities and calibrated in avoirdupois as well as in metric units.

The *du Nouy Tensiometer (Central Scientific Co.)* is a direct reading surface tension balance of the torsion type. A platinum dip ring (Fig. 42) is supported at the end of a long lever arm which is clamped to the mid point of a stretched torsion wire one end of which is fastened to the balance frame. The other end is attached to a rotating indicator which moves across a calibrated scale graduated in dynes per centimeter. In use, the indicator is rotated through a worm wheel drive until the ring is pulled away from the liquid and the torsional force just overcomes the surface tension. The range is 100 dynes with vernier reading to 0.1 dyne. Readings can be made in about ½ minute. The balance is also furnished with the dial calibrated in angular degrees. This balance while admirably suited for the measurement of surface tensions of ordinary solutions, is not recommended, although it can be used, for syrupy liquids, due to the change in cross section of the elevated film. For precautions to be observed under these conditions the original literature should be consulted.*

In the *Chainomatic Surface Tension Balance (Becker)* the left pan of the notched beam chainomatic analytical balance is replaced by a platinum ring which is dipped into the liquid, the surface tension of which is to be determined. The liquid is placed in a container on the elevating platform immediately below the ring and the container lowered until the ring is at the surface of the liquid. The force required to pull the ring from the liquid is then measured directly (in g. to the fourth decimal place) by using the balance in the usual way. The chainomatic feature permits of a very gradu-

* Ferguson, *Science Progress*, Vol. IX (1915) page 428.
P. L. Nouy. *Journal General Physiology*, Vol. I (1919) page 521.
P. L. du Nouy. *Science*, Vol. 59 (1924) page 580.
P. E. Klopsteg. *Science*, Vol. 63, June 11, 1926.

al increase in the pull and so records the tension at the moment of break.

Triple Beam Balances see Multiple Beam Balances.

Technical Precision Balances are the grown up brothers of the analytical balance. They range in capacity from the heavy capacity analytical balance of 500 g. load, to the bullion and specie balances of 200 to 10,000 oz. capacity. These balances are remarkably rugged in construction and of exceptional sensitivity. One 2 kg. balance (*Becker*) has a sensitivity of 1/5 mg. while the 10,000 oz. balance (*Troemner*) is sensitive to 4.8 grains. The smaller ones are recommended for the calibration of volumetric flasks and the weighing of large bulk samples, while the larger ones are used for the weighing of gold and silver bar, specie, plated ware, etc. where large capacity of balance and bulky samples are involved.

Unit Weight Over-and-Under Balances and Scales. These balances are frequently referred to as "automatic even balance scales" and are examplified by the Dayton scale. In principle they are similar to the Harvard Trip balances in construction but differ from it in what they have the indicator arm quite long, and usually enclosed in a case. The end of the arm moves across a scale divided into small units and is graduated on both sides of a central zero point. In use the load to be weighed is put on the scale pan as usual and counterpoised with the necessary weights The indicator arm then moves across its scale and indicates the quantity over or under the unit weight as established by the weights added to the pan. This type comes in many different capacities, avoirdupois and metric, with an average accuracy of about one part in two hundred. Special models with greater accuracy with computing, counting and value charts built into the indicator scale are available to order. These balances and scales are particularly useful in control laboratories for the routine weighing of samples with moderate accuracy, where the amount of the over or under weight is well within the tolerance of the test. Recommended uses are the checking of standard packages, bottles and cans of bulk products, seeds, oils, soaps etc.

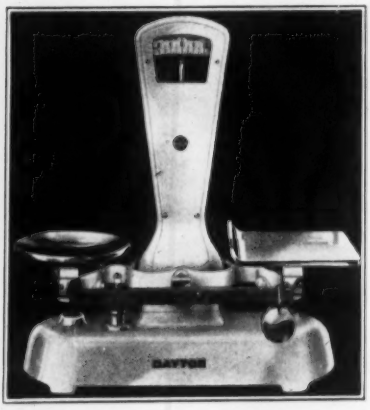


Fig. 44. Unit Weight Balance (*Dayton Scale Co.*)

The *Wood Moisture Balance*, a simple device for reading directly the trend of moisture content of wood in the woodworking shop, dry shed, or storage shed, is a recent contribution of the U. S. Forest Products Laboratory to wood seasoning technique. The value of the device is based on the well-known fact that there is a definite moisture content for wood—the equilibrium moisture content—corresponding to any given combination of relative humidity and temperature—the equilibrium moisture content of wood in a room at 70°F. and 30% relative humidity is, for instance, a trifle over 6%.

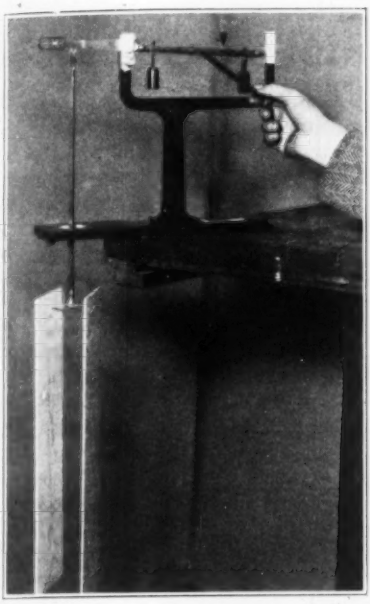


Fig. 45. Wood Moisture Balance (*Forest Products Laboratory*)

For measuring the moisture content which the wood near by is attempting to reach—a good gage of the severity of drying conditions—reading of the balance is much more simple and direct than cutting and determining moisture content on wood samples or computing atmospheric humidity and corresponding wood moisture from wet-bulb and dry-bulb thermometer readings.

The wood moisture balance consists essentially of any kind of simple balance on one side of which is suspended a strip of wood cut to a calculated weight of exactly 100 grams, ounces, or other convenient unit when oven dry. If the wood is thin—say $\frac{1}{8}$" in thickness—and its oven-dry weight is offset by a corresponding weight on the opposite side of the beam, the moisture which it picks up to come to equilibrium with the surrounding air can be determined directly in % of oven-dry weight of the wood by balancing the wood with weights added to the 100 units already on the opposite side of the beam. In the case of a spring balance, subtracting the oven dry weight of the wood from the reading would give the moisture %.

Equipped with a very thin strip of wood the wood moisture balance acts quickly enough to be said to show equilibrium moisture content practically at the moment of reading. Provided with a thicker piece which changes more slowly, any given reading averages the effect on the wood of atmospheric conditions for some time (length of time increasing with thickness of the wood) previous to the reading. When special sensitiveness is desired it is best to use sapwood of a species which responds quickly to moisture changes.

Illinois Testing Laboratories, Inc., 141 W. Austin Avenue, Chicago, Illinois has appointed Porter Hurd, 516 Packard Building, Philadelphia, Pennsylvania, as its representative in Eastern Pennsylvania, Southern New Jersey, Delaware and Maryland for its line of portable and stationary indicating pyrometers, resistance thermometers and other measuring instruments for industrial purposes.

A New Method of Pivoting on Instruments

*A. J. Lush**

IT seems hardly possible to make and substantiate any really worth while claims of superiority for one type of meter pivot over another, and yet too great an emphasis can not be placed on this most vital point in meter movement design and construction.

Constancy of calibration is one of the most necessary, if not the first, requisite of a good meter. There are various things governing this, such as permanency of magnetic flux, quality and temper of springs used, freedom from outside-of-meter disturbances, good joints in the electrical circuit, variable temperatures changing both the electrical resistance of the circuit and also the actual linear dimensions of the pivot settings on the movement itself (see reference below), but perhaps something which has not been previously emphasized as much as it might on account of difficulties of construction is the actual position taken up by the pivots upon which the movement turns.

It is not the purpose of this article to apply this reasoning to meters of the vertical type as these are usually hung in a fixed definite position when calibrated and used in a similar position only, but when meters are intended for portable use or for horizontal use, such as in test sets, the meter can not be guaranteed to be placed in exactly the same relative position or level as when originally calibrated. It is here that is position of pivots within their jeweled bearings is of vital importance. Any other position taken up by the movement than that in which it was calibrated will very obviously affect the constancy of calibration.

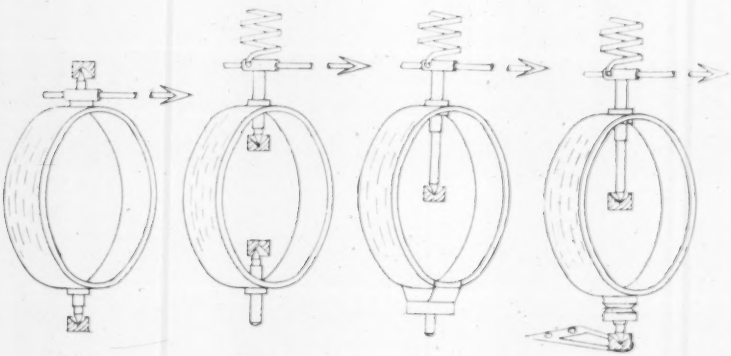


Fig 1. Fig 2. Fig 3. Fig 4.

Four entirely different methods of pivot mounting are shown in the illustrations. Figs. 1, 2 and 3 show the old conventional methods of mounting which have done valiant service in past years. Figs. 1 and 2 can be relied upon where there is a strong control necessitating a strong spring which in turn tends to hold the movement in a definite position, but this is not the case where high sensitivity is desired, say below 1 milliamp. full scale. Reference to Fig. 1 will show the lower pivot, which supports the

*Rawson Electrical Instrument Company

weight of the movement to be resting on its extreme tip and in contact with the apex of the jewel bearing which is of course as it should be, but observe the unstable position of the top pivot which merely acts as a guide. On account of the impossibility of tightening the top jewel down to bring pivot to apex of bearing, this pivot is liable to wobble around anywhere within the area of loose fitting of pivot to jewel. This can not be avoided as should the jewel be tightened down, very undesirable friction would immediately appear. Furthermore a feature which is sometimes lost sight of is the linear expansion and contraction of the whole moving coil which, of course, includes the dimensions between pivots due to changes in temperature. This latter condition has been the cause of trouble in the past evidenced by the movement sticking over scale reading when meters have been used at varying temperatures. To avoid this entails loosening the fit of pivots to jewels still more with its larger area of uncontrolled movement of the guide pivot. One more feature must be considered that of total frictional moment which may be considered in simple form as $= 2/3\ \mu Wr$ where μ is the coefficient of friction for the materials used, W the weight and r the radius of surface contact. While the lower pivot carries the greater portion of the weight, r is at the lowest value possible as the movement is resting on the extreme point of pivot the only measurable surface being due to the crushing effect of the movement weight (a good hard pivot and high quality well polished jewel will reduce this to a minimum). The upper pivot however, while only carrying a small portion of the weight, has an enormously larger r, rolling around within its loose area of contact. Hence in order to overcome frictional trouble, a much stronger control is necessary. This is usually attained at the expense of clearances within the gap in which the movement turns, the with detrimental feature of causing sticking of movement on sides of gap or on minute particles of dust, but if given the larger clearances movement would easily ride over without touching.

All of the above remarks apply equally well to the movement shown in Fig. 2 with the exception that in this case the top pivot carries most of the weight and the bottom pivot wobbles around.

Fig. 3 shows the single pivot movement which eliminates the loose fitting second pivot feature and claims the very acceptable addition of its adaptability to clamping for transit which by lifting the weight of the movement relieves the pressure between pivot and jewel while the meter is in transit. All clamping has for its object the protection of pivots from damage while being shipped from one place to another. So-called electrical clamping which is a device for short circuiting the moving coil causing excessive damping, will not take care of this as it only protects the pointer from bending due to excessive slamming by jarring in shipment, the weight of the movement still being carried by the pivots.

Some time ago the author was confronted with the problem of developing a high sensitivity electrostatic voltmeter. Anyone familiar with this type of meter will recognize that every one of the above remarks play a very important part therein. In line with this he devised a means of eliminating the detrimental features while still retaining the valuable clamping feature. A single pivot movement was out of the question on account of the possible sideways or oscillating motion which is not a serious objection on that type of movement as the pivot being in the center of a spherical magnetic field, all parts of the deflection coil remain at equal radii distances in the field at all times. The principle of balancing the whole of the movement weight on

one central pivot was retained with another pivot added to act as a guide which, however, would at all times be in intimate contact at its extreme point with the apex of the jewel bearing, this latter feature being attained by supporting the jewel on a very resiliant but weak spring incapable of supporting the weight of movement. On account of special construction this spring could not move in a lateral direction being limited upwards by the pivot and downwards slightly below the hanging point of pivot by a solid stop, thereby eliminating the possibility of jumping out of reach of the pivot. As both pivots were in the same direction or downwards this permitted design of a clamping device similar to that used on the single pivot movements, all of the weight being lifted from the main or central pivot, leaving only the very light spring holding the lower jewel against the lower pivot which could not possibly damage the latter pivot in any way. When unclamped, relative position of pivots in both bearings was maintained as both pivots were in intimate contact with the apex of their jewel bearings, thereby removing any possibility of calibration error due to a variable change of position of moving element within its field. The same principle was applied to a fluxmeter and then to the regular line of micro- and milliammeters, etc., where it has lent itself to removing the slight up and down motion characteristic of the single pivot movement. Of course this type of movement can only be used in meters intended for reading in a horizontal or approximately horizontal position.

Fig. 4 shows the latest arrangement of this development on the standard microammeter movement.

It is planned, pending ratification by stockholders of the respective corporations at their annual meetings, that the Minneapolis-Honeywell Regulator Company will acquire all the properties and business of the Time-O-Stat Controls Corporation, the latter organization to be operated as a division of the Minneapolis Company.

It is expected that improvements in temperature controlling devices can be developed and perfected much more rapidly in consequence of having the great engineering departments of these 2 leaders in the industry working harmoniously together.

The Minneapolis-Honeywell line will now comprise the Time-O-Stat gas hot-water heater control, mercury tube switch devices, refrigeration controls, and electric sign flashers, in addition to its former line of damper regulators, controls for oil or gas burners, unit heater and sectional controls, stoker controls, individual radiator controls, and motorized valves and controllers for industrial processes.

Illinois Testing Laboratories, Inc., of 141 W. Austin Avenue, Chicago, Illinois, announces through its Sales Manager, M. D. Pugh, the appointment of James H. Knapp Co. 4920 Loma Vista Avenue, Los Angeles with a branch in San Francisco, as its exclusive Pacific Coast distributor of its products for industrial purposes, consisting of "Alnor" and "Price" portable and stationary Indicating Pyrometers, Resistance Thermometers and other electrical and magnetic measuring instruments.

The Bailey Meter Company of Cleveland, Ohio announces the appointment of P. S. Dickey as Research Engineer. Mr. Dickey is a graduate in Mechanical Engineering of Purdue University, and during the past few years has been specializing on Automatic Combustion Control problems for the Bailey Meter Company.

NEW INSTRUMENTS

Recently Developed by Instrument Manufacturers

Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional information.

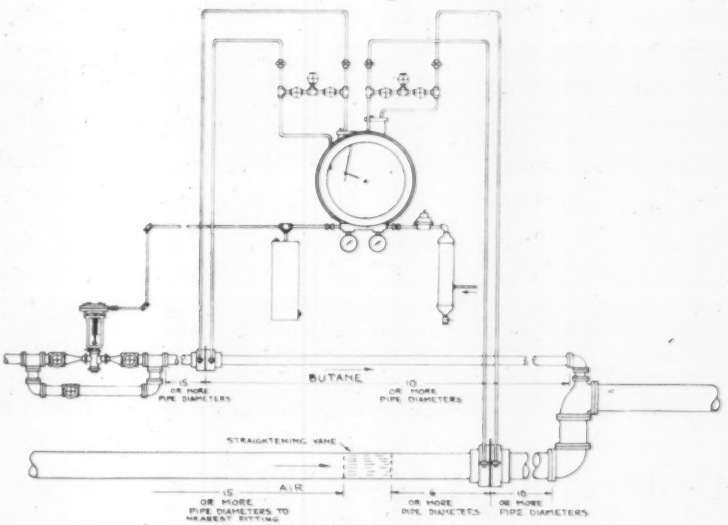
Air-Butane Ratio Controller

(Foxboro Company)

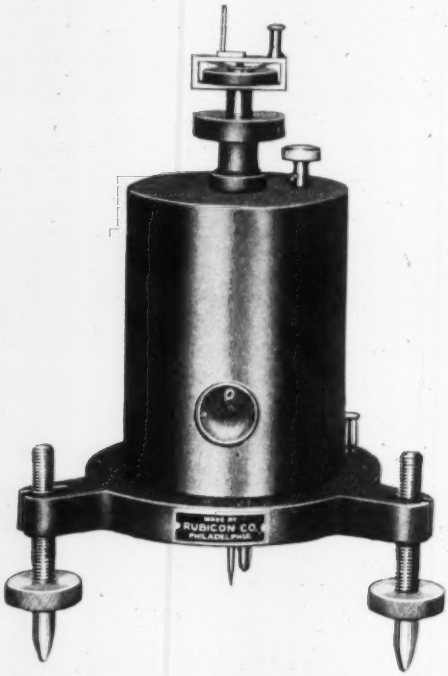
THIS instrument will automatically mix butane and air in the proper ratio where air-butane plants are being set up to supply gas to small communities. This instrument is called a ratio-flow recorder-controller and is based on the orifice principle.

Like all other Foxboro controllers it operates a controlled valve with air or gas under 15 lbs. / in.² pressure. In its essentials, the ratio controller is 2 instruments in 1—a flow meter and a flow controller.

The figure shows a typical layout. The meter side of the instrument is connected to an orifice flange union in the air line. The controller side is connected to an orifice flange union in the butane line. Both orifice plates are on the suction side of the booster; therefore, the downstream or static pressure in both lines is the same and the resulting ratio of volume or B. T. U.'s. is constant. As the demand or load varies the differential across the orifice in the air line will change. This change will reset the control point and cause the flow controller to re-adjust the controlled valve, thus maintaining the required ratio.


BUTANE
15 OR MORE PIPE DIAMETERS
10 OR MORE PIPE DIAMETERS
STRAIGHTENING VANE
AIR
15 OR MORE PIPE DIAMETERS TO NEAREST FITTING
6 OR MORE PIPE DIAMETERS
10 OR MORE PIPE DIAMETERS

This ratio controller is equipped with 2 pens, one operated by the meter which gives a record of the changes in differential pressure of the air and the other attached to the controller which gives a record of the butane differential pressure changes. Both pens will record approximately the same differential pressure if the correct ratio is being maintained. To remove the difficulty of reading the chart with one record appearing directly over the other the pens of this ratio controller have been adjusted to operate 10 divisions apart for the same differential reading. A special chart to allow for accurate readings has been provided to take care of this difference.



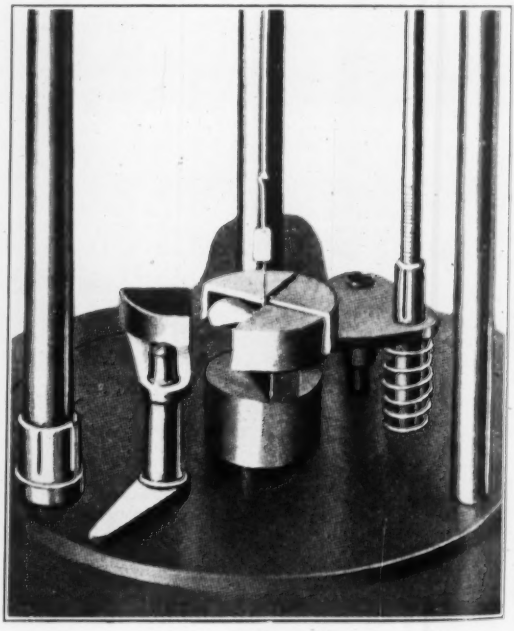
Compton Electrometer

(*Rubicon Company.*)

THE Compton electrometer is of the well known quadrant type originally invented by Lord Kelvin. It is probably the most sensitive electrostatic instrument available, yet is not difficult to use. Its outstanding features are the small size of the electrical system resulting in an extremely small capacity (about 12 cms) and the ease with which the sensitivity can be adjusted to suit given working conditions. The adjustment of the sensitivity is effected by means of what is known as "electro- static control", and this adjustment can be made while the apparatus is connected in the working circuit. Sensitivities as high as 50,000 mms per volt have been obtained with one of the experimental models.

In its construction the Compton electrometer is remarkably simple. Two of the 4 quadrants are insulated from the case by a block of genuine amber, the other 2 quadrants being grounded. The arrangement is such that one of the grounded quadrants may be pushed aside or removed altogether when suspending the needle. The fourth quadrant is adjustable in a vertical direction, and may be raised or lowered from the outside of the case for the purpose of adjusting the sensitivity.

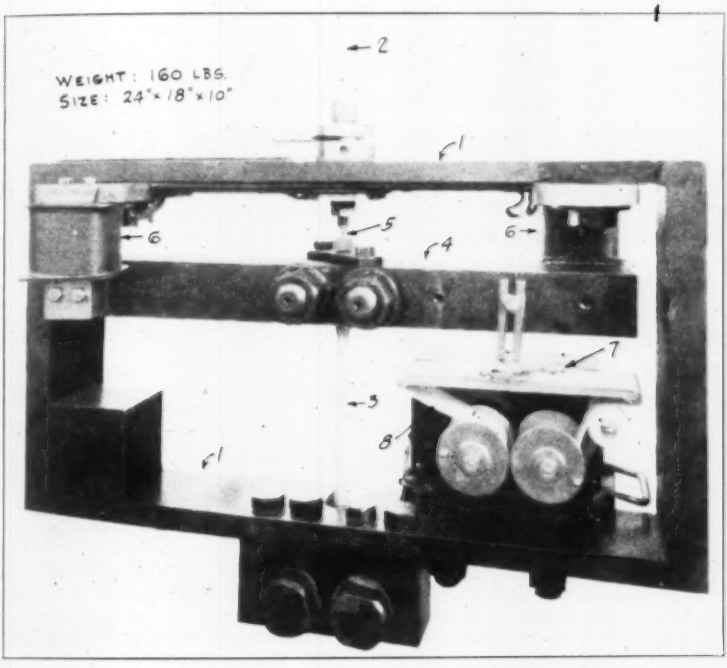
The moving system consists of 2 separate parts—the needle and the suspension. The needle is a very light vane of aluminum leaf to which is attached a light metal shaft carrying a small mirror. The suspension is a fine fiber rendered conducting by sputtering with platinum in vacuum. At one end the suspension carries a fine silver hook from which the needle is suspended. The other end of the suspension is attached to a metal pin which is held by a miniature chuck insulated from the case. Provision is made for adjusting both the height and the angular position of the needle from the outside of the case.



Foeppl-Pertz Damping Tester

(*Southwark Foundry & Machine Co.*)

THE Foeppl-Pertz damping machine consists of a frame (1), hung from the ceiling on a wire (2) about 10 ft. long. This unusual way of mounting the machine is one of the special features which provide the high accuracy needed in determining the small amounts of work absorbed by internal friction in the specimen (3). The test rod (3) is rigidly clamped on its bottom into the frame (1) by means of heavy screws and carries on its top an oscillating mass (4), which makes a reciprocating rotary movement about the axis of the specimen, twisting the same back and forth. A small pivot (5) avoids any lateral movements, so that the stresses in the specimen are purely torsional. The test itself is started by twisting the mass (4) to a desired amount and holding it in a twisted position by means of adjustable electro-magnets (6). Upon breaking the electrical circuit of which the magnets' coils are a part, a free oscillation is produced. The stylograph (7) attached to the mass (4) records a damped free vibration diagram on the chart moved by the clockwork (8).



These curves are obtained in a few minutes and represent the damping characteristic of the material which can be replotted in the form of diagrams, showing the amount of work absorbed in relation to the rate of stress.

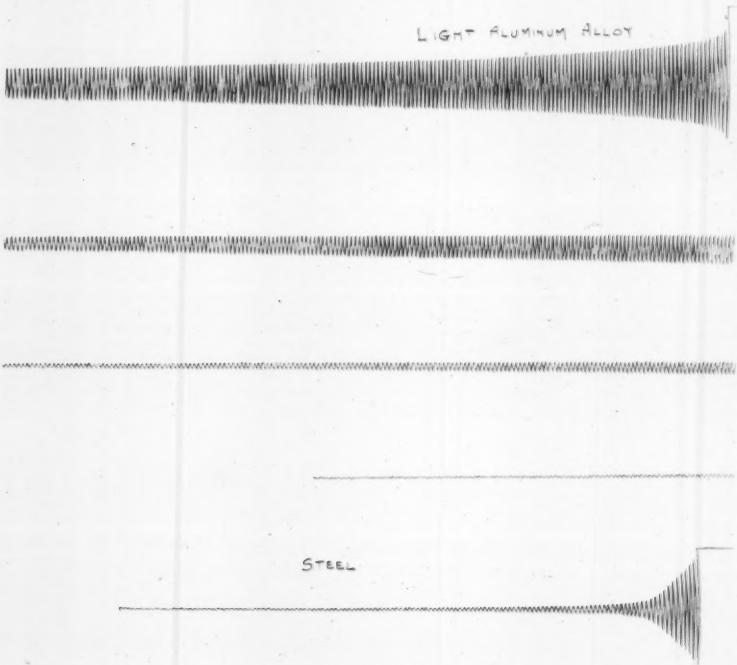
The machine determines internal frictional losses of materials, which are also represented by the well known hysteresis loop. The method, as described herein, was developed at the Woehler Institute and after years of careful checking work by comparison with four other methods, represents the most practical way of measuring the internal friction.

The internal friction is of direct importance for damping critical vibrations which occur in service with crank shafts, turbine blades and other repeatedly highly stressed machine parts. A machine part with a high internal friction or damping capacity, keeps the amplitudes in a range where no failure may be expected.

It may happen that a material with a higher fatigue limit breaks as the resonance stresses exceed the safety range; but a material with a lower fatigue limit and with higher internal friction damps the critical vibration to such a degree that even the lower fatigue range is not exceeded and the material does not fail.

There is, furthermore, a fundamental connection between the elastic properties found in the usual static test and this new test. This test automatically measures the area of static stress-strain diagrams, which represents the absorbed work. It has been found that the internal friction starts at very low stresses; as a matter of fact, far below the so-called yield point.

This test, therefore, reveals once more, in a particularly accurate form, that Hooke's law is merely an approximation. The actual behavior of structural materials deviates from Hooke's straight line and this test shows how much and how it varies for different materials within the working stress range. It requires the most refined extensometers and much patience to discover these minute deviations in any other test; while with this test it is surprisingly simple.



Curves obtained with Damping Tester

The test is non-destructive and its result is a physical property; viz., the internal absorption of energy, due to friction or inelastic action. This quality is not the result of local conditions, as are the breaking stresses in static and fatigue tests; but it refers to the total volume of the material as the modulus of elasticity, or Poisson's ratio do.

In other words, this test means a novel method of investigating the stress range, practically used in service, which excels in accuracy, sensitivity and simplicity.

The new method also seems to have particular promise for the study of internal or external stress concentrations, due to flaws or surface damages. This has been shown by a number of tests recently made at Prof. Foeppl's laboratory.

Correction

On page 779 of the December 1930 issue is a description of Model 565 Radio Equipment Tester of the Weston Electrical Instrument Corporation. We inadvertently used the illustration of the Model 566, which is a two meter set.

Light Weight Volt-Ammeter for Airplane Battery Circuits

IN certain types of airplanes it has been customary to provide in the battery circuit a direct current ammeter for indicating the charging rate or the current drain upon the battery, and a D.C. voltmeter for indicating the voltage of the battery. Two separate instruments have heretofore been provided, the ammeter usually being a flush mounted 2½" diameter instrument of the D'Arsonval type calibrated 30-0-30 amperes or 50-0-50 amperes, and the voltmeter being calibrated 0-20 volts or other voltage as required by the number of cells used.

The Westinghouse type BX volt-ammeter recently developed combines these two in-

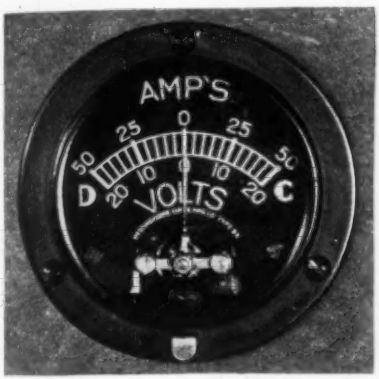


Figure 1. This combined voltmeter and ammeter weighs only seven ounces. Dial is marked with luminous paint.

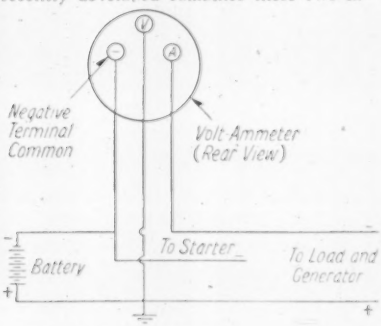


Figure 2. Method of connecting instrument in battery circuit. The instrument normally indicates amperes. To read volts a button is pressed.

struments in one, thereby reducing the weight of the total equipment to about one-half of its former value. The new instrument weighs 7 oz. complete with all terminal clips and mounting screws. It is entirely self-contained, and the dial is marked 50-0-50 amperes and 20-0-20 volts as shown in Fig. 1. This particular instrument is designed for use with a 12 volt battery but other combinations of ranges are made for different battery voltage or current requirements.

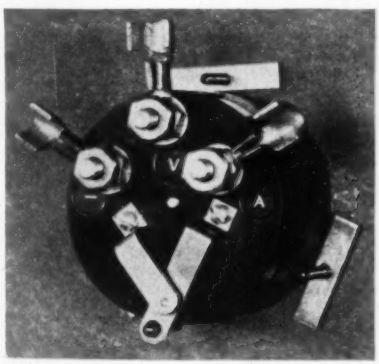


Figure 3. Rear view of volt-ammeter hoswing terminals and push button. The coil of the instrument is switched from current circuit to voltage circuit by pressing the push button without opening the battery circuits.

Fig. 2 shows the method of connecting the instrument in a battery circuit. Assuming the positive terminal of the battery to be grounded, the common terminal of the instrument is made negative and connections are made fundamentally as shown. The instrument normally indicates amperes, either charge or discharge, but upon pressing the push-button the instrument indicates battery voltage.

A reading of battery voltage is of great value in determining the condition of the battery or in locating trouble such as a loose joint, a defective cutout, or a broken wire. With the generator switched off or not running, and with a normal load upon the battery, it is possible to tell roughly the amount of charge in the battery by reading its voltage. A battery which is nearly exhausted will read several volts lower than one which is fully charged. If a defective connection develops around the battery terminals, the voltmeter reading will be considerably higher than the maximum battery

voltage when the generator is running. In case of a broken wire near the battery the voltmeter will indicate generator voltage or will go completely off scale showing the nature of the fault.

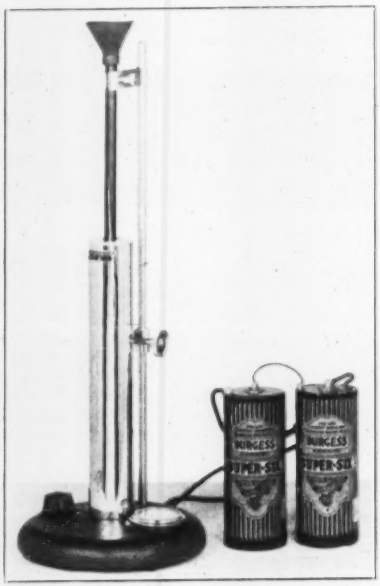
The combination of a voltmeter and an ammeter in this extremely small space was made possible by the development of a high resistance winding suitable for both voltage and current measurement. The instrument contains a heavy shunt which is connected across the meter mechanism, also a resistance spool which is connected in series with the mechanism. The mechanism is changed from one circuit to the other by a simple built-in push-button which is very light in weight and which requires no extra wiring or mounting. Figure 3 shows the rear of the instrument with the push-button at the bottom and the 3 terminal studs at the top. Heavy copper terminal clips are provided for attaching wiring to these terminals.

The dial of the instrument is provided with luminous markings on a black background. An external zero adjuster is provided, and the terminals are marked as indicated in Figs. 2 and 3 for battery circuits having the positive side of the battery connected to ground.

New Turbidimeter

(*Burgess-Parr Co.*)

THIS turbidimeter based upon the Parr sulphur photometer, which it replaces, is an instrument developed for measuring the turbidity of solutions, particularly those solutions on which the turbidity is relatively high. It was developed originally to provide a rapid method for the analysis of sulphur in fuels by using the oxygen bomb washings from a B. T. U. determination on the peroxide fusion of the Burgess-Parr sulphur bomb. Barium chloride crystals are introduced into the test solution, causing a fine precipitate of barium sulphate which will remain in suspension sufficiently long for several check determinations. This solution is poured into the solution tube, which is placed in operation and the plunger tube brought to the bottom by a gear and rack mechanism. An electric filament lamp located in the base of the instrument is operated from two dry cells and by means of a voltmeter and a rheostat, the lamp voltage is controlled. With the lamp voltage set at a predetermined point and the eye-piece tube properly located, the operator raises the plunger tube by means of a gear and rack mechanism until the turbid solution introduced between the bottoms of the solution tube and the plunger tube is sufficient to cause the disappearance of the lamp filament. The distance between the two tubes is then read directly on a scale mounted vertically in the instrument and by referring to a chart provided with the instrument, the quantity of sulphur or sulphate can be determined.



The instrument finds application in the analysis of fuels for sulphur content for the sulphur content of cement and for the quantity of sodium sulphate in boiler waters. This last application is of increasing importance, inasmuch as it provides one method to guard against caustic embrittlement. Other applications, such as the determination of sulphate content of chromium plating solutions, sulphate content of sulphite liquors, etc. are being investigated. Other turbidity measurements will, undoubtedly, be developed and it is expected that the instrument will provide a means for speeding up many laboratory procedures.

The outstanding advantage of the Burgess-Parr Turbidimeter for sulphur and sulphate analyses is speed of operation. Its accuracy is comparable to ordinary laboratory procedure and its simplicity of construction and convenience of operation makes its use desirable. The fact that it does not require a trained chemist to operate it, extends its field of usefulness to many industries.

Instrument Protection With Fuses

*E. V. Sundt**

ELECTRICAL instrument protection resolves itself roughly into two problems: One to prevent the burning or overheating of fine wires, springs, etc., which are a part of the instrument, and the other to prevent injury to the moving parts when the instrument is subjected to a sudden heavy overload.

As a general rule the latter problem is the most difficult one to solve. That is because in the vast majority of electrical instruments on the market the smallest copper wire used is about No. 44 B. & S. and the smallest phosphor bronze spring is about No. 38 B. & S. Both of these materials will carry one ampere of current for a short period of time (0.1 second) without injury. To construct a fuse that will act quickly enough to meet this condition is comparatively simple. To meet the other condition is altogether different. Some of our little 0-1 milliameters flip across the scale in .001 second under a short circuit of about 100 volts and the higher the voltage the quicker they flip. A fuse to adequately protect it must open the circuit in less time than that.

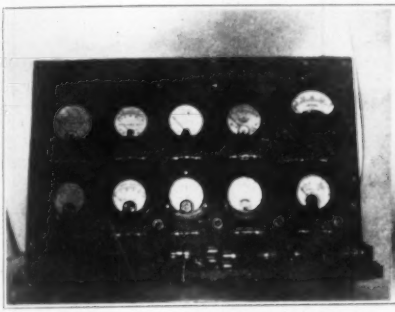


Fig. 1. This is the test set used to inspect Littelfuses and to determine the blowing characteristics of various kinds of fuse filaments. Each meter is protected by a Littelfuse directly below it. Here also is determined the capacity of fuses required to protect various instrument ranges. In the lower center is a Littelfuse being tested. On the lower right are three of the new High-Voltage Littelfuses for use on 1000 to 10,000 volts.

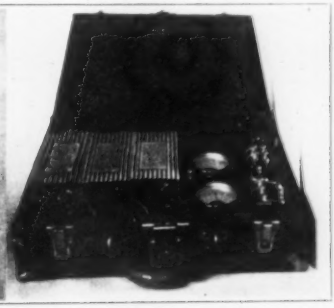


Fig. 2. This picture is of a demonstration set where hundreds of 1/32 amp. Littelfuses have blown protecting a 300-30 galvanometer (22 microamperes per division) against a short-circuit of 135 volts. The upper meter is a 0-10 milliammeter which is protected on demonstrations by a ¼ amp. Littelfuse. Both instruments still function perfectly. The fuse is shown at the right.

Delicate equipment protection therefore is purely a time proposition. Under a short circuit the fuse must go before the instrument does. The fuse may be rated at ¼ ampere but the voltage may be high enough to produce a peak surge of 1 ampere under a short. Nevertheless if the fuse is quick enough the instrument will be intact—because *not enough energy* has passed to build up a magnetic field in the armature, overcome the inertia of the needle and moving parts, or create other damage. It is somewhat analagous to the lightning flash which comes with billions of volts and hundreds of amperes, but is of such short duration that the total amount of energy isn't worth fifteen cents.

For that reason no matter what the rating of the fuse may be, unless its time lag in blowing is very small it is useless in delicate equipment protection. A time lag however is quite an advantage in circuits of 10 amperes or more.

Since it is impossible to obtain a wire for fuse elements which will blow at 1/100 of an ampere various methods must be used to obtain this end.

One method is to use a silk or glass fibre which has been metallized for a fuse element. Another method used is to use a resistance wire on which is applied a highly combustible substance. When the wire reaches a predetermined temperature this substance ignites and

*Littelfuse Laboratories.

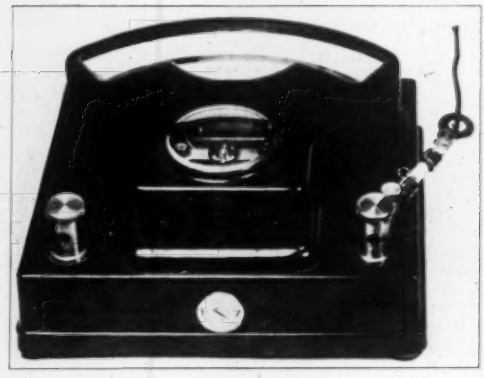


Fig 3

burns the wire apart. Also the wire is coiled in a manner similar to that used in incandescent lamps in order to concentrate the heat and to secure fusion or ignition, as the case may be, on smaller currents than would be possible with straight wire.

The voltage under which a fuse may be used without drawing an arc varies a great deal with the resistance of the circuit, the resistance acting as a ballast when the fuse is blown and prevents an arc. It is often well to put a large wattage lamp in series with the instrument to act as a ballast. The voltage drop across the lamp being negligible with normal current drain.

The tendency to arc also drops rapidly as the current values are decreased. Two or more fuses in series may also be used on high voltage as a temporary expedient. Thus two $\frac{1}{8}$ amp. fuses, which are suitable for use on 1,000 volts singly, may be used in a 2,000 volt circuit in series.

Round-O-Meter

(Automatic Maintenance Machinery Co.)

A NEW direct reading indicator that checks roundness and size of any round object from $\frac{3}{4}$" to 6" in diameter, and gives accurate readings to half thousandths of an inch.

The instrument requires no skill to operate. There is no chance of error. It instantly gives the operator an accurate picture of roundness of pistons, bushings, sleeves, bearings, pins, and all round parts.

The Round-O-Meter increase the speed and accuracy of inspection work in manufacturing plants, eliminates the uncertainty and errors of outside micrometer measurements, and permits unskilled operators to do precision inspection work without special training in reading micrometers.

By using Ammco gage setting rings, the Round-O-Meter can also be used for direct measurement and comparative checking. Gage setting rings are furnished in any specified diameters oversizes or under-sizes, within the range of from $\frac{3}{4}$" to 6" inclusive.

New Wash-Wheel Thermometer

(Foxboro Company)

THIS new thermometer presents many tried and tested features. Above all it is easy to install, taking only a few minutes. Once installed, it cannot be injured by contact with the cylinder, closing or opening of the door while the cylinder is still in motion. It is extremely sensitive and is accurate within very close limits throughout its entire scale range. It can be easily read more than 20 feet away and it has the longest working scale of any thermometer of its size. This thermometer will remain accurate under the most trying conditions, and is readily adaptable to either a wood or metal wheel. A flange connection makes this possible. For metal wheels it is furnished with a union connection.

Direct Current Volt-Ohmmeter

(Roller Smith Company)

THIS instrument may be used for continuity testing, as a direct reading ohmmeter or for reading voltages up to 600 volts, direct current. It is recommended particularly for radio testing. The voltage ranges have a resistance of 1,000 ohms per volt.

The instrument is a Type PD four range voltmeter with ranges of 0-3, 0-30, 0-300 and 0-600 volts. It is also a direct reading ohmmeter with ranges of 0-10,000 and 0-100,000 ohms. To change from one ohm scale to another it is necessary simply to rotate a knob located at the top of the instrument. The instrument measures $4\frac{1}{2}$" wide, 5" long and $2\frac{5}{8}$" deep and weighs approximately 2.9 lbs. The long scale ($3\frac{5}{16}$") will prove to be highly advantageous when reading resistances on the ohm scales. The instrument contains a 4.5 volt C radio battery which can be procured at practically any electrical supply store. To replace the battery it is necessary only to remove the back half of the instrument base and slip out the old cell.

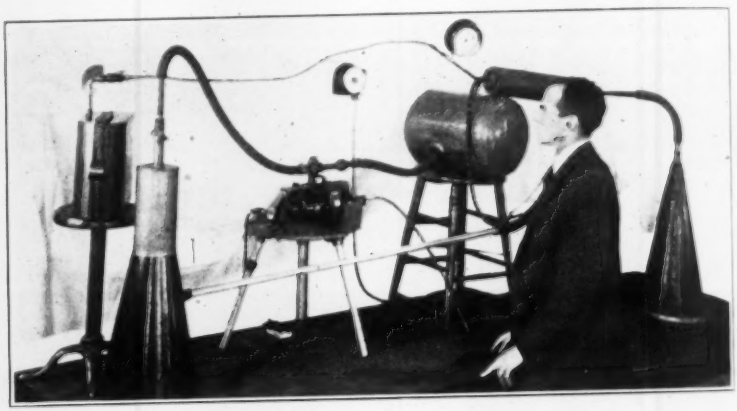
To compensate for the falling off in cell voltage, which occurs after the instrument has been in use for a time, a special type of rheostat is included, which can be manipulated by a screw driver from the top end of the case. The binding posts used for resistance measurements when short circuited permit the needle to go to "zero" ohms. If the needle falls short of the zero mark rotating the rheostat screw will cut out resistance and raise the voltage and give full scale deflection. A pair of special flexible cables with insulated test prods accompanies each instrument.

Sonic Altimeter

THE echo, heretofore of value largely for the amusement of curious mountain climbers and visitors to whispering galleries, is put to practical use in a new device developed by the General Electric Company and tested by the air corps of the United States Army, the new instrument, the design of which takes a hint from the bat, permits the pilot of an airplane, while landing in a dense fog, to determine at any instant his height above the ground.

The operation of the device is simple: it merely shoots a sound wave to the ground, catches it on the rebound and measures the time consumed in the round trip of the sound. The instrument is called a sonic altimeter, and its operation is analagous to the method which supplies bats with their uncanny ability to avoid obstacles in their weird and seemingly erratic flights. It is generally assumed that the bat, while flying, emits a sound too high in pitch for human ears to hear, which is echoed back from the surface of surrounding obstacles, thus enabling the animal to sense the proximity of an object.

By analogy the engineers of the General Electric Company built a sonic altimeter having a whistle which is blown at regular intervals by power from the engine of the airplane. With this is provided a means for catching the echo and, for altitudes greater than 50 feet, a dial on which may be read the altitude.



The dial indicator is very useful when the airplane is flown over a mountain range or from a field at one altitude to another of different altitude, in the obscurity of fog or at night. The radio beacon is sufficient to guide the airplane through fog or clouds to its destination. Automatic pilots, the artificial horizon and other blind flying instruments either being tested or developed, make level flight possible under conditions of no visibility. But the greatest problem, and until now unsolved, was to land after finding the way to the fog-bound airdrome. This, it is believed, the sonic altimeter will now make possible. Having arrived over the airdrome the boundaries of which are made known to the pilot by an electro-magnetic field, the airplane is brought down until the sonic altimeter shows that it is at a height of about 200 feet. The engine is then throttled or slowed down and the airplane is allowed to settle in a normal glide.

Here is where the sonic altimeter is called upon for its best service. The time interval between the whistle emitted from the airplane and the echo which is picked up by the pilot, is a measure of the height. As the airplane nears the ground this interval becomes shorter and shorter until, at a height of about four or five feet, the whistle and echo blend into one combined note. The pilot knows at this time that he can pull back on the stick and settle or "pancake" to the ground.

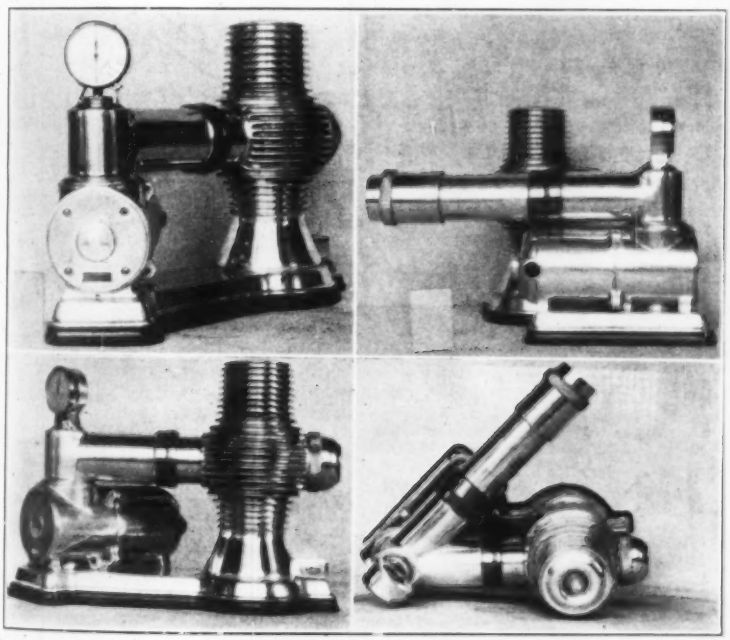
Further tests are being made with a view to simplification of the apparatus and to reduction of weight in order that the sonic altimeter can eventually be placed on the market for installation on any airplane.

The Tackiscope

(Robert Donner)

THE Tackiscope has been developed to enable one or several observers to study the successive phases of varying motion through the projection of interrupted light flashes upon the object. When the instrument is so adjusted that these periodic flashes have a proper synchronous frequency the moving body apparently stands still; or it can be made to appear moving slowly either forward or backward as the operator wills. It is an application of the same principle for producing the illusion of motion by a series of pictures viewed in rapid succession.

We see an object by virtue of the light rays reflected from its surfaces to the retina of the eye. While the travel of light is practically instantaneous, being approximately 186,000 miles per second, the time required for the impulse to reach the brain and register is appreciable; when this light impulse ceases the reflected image remains in the brain for some considerable length of time. This interval is known as "persistence of vision," and its duration is variable depending somewhat upon the individual. No very reliable figures are available, but it is estimated at about $\frac{1}{15}$th of a second. When, therefore, an object is revolving at a speed of more than 300 revolutions a minute this persistence of vision compels us to see successive portions of the path of image simultaneously and results in a confused blur of the rotating part.



The Tackiscope is so arranged that the light reflected from the object under observation reaches the eye only for a very short period of time during each revolution and we depend upon the persistence of vision to give the mental effect of a continuous picture. The length of time must be short enough to eliminate all blur, but long enough to permit sufficient light to be reflected from the object. This delicate operation is effected by mechanical interruption of light reflected from a 200 watt incandescent lamp against a high speed revolving mirror or mirrors, the number of separate and distinct flashes being made to correspond exactly with the revolutions of the moving part. The velocity of this revolving mirror, which has a speed range from zero up to 33,000 revolutions per minute, permits of rapid synchronization and is controlled by a small friction drive disk at the back of the instrument. This mechanism is so sensitive and nicely adjusted that its slightest movement enables the operator to follow the moving part, whatever its velocity, and cause it to appear stationary, or turning slowly, forward or backward.

By merely pressing a button on the side of the tachometer the revolutions per minute (R.P.M.) of the moving body can be quickly and accurately recorded. No contact with the part being examined is necessary. The actual reading of the speed may be taken later as the hand on the dial stays in position until the button is again pressed for another reading.

The instrument is conveniently portable, and can be plugged into any ordinary electric light socket, taking either direct or alternating 25 to 60 cycle service. Its size is 14″ by 11″ overall and weighs less than 12 lbs. complete. The case or outer shell is made of cast and tubular aluminum alloy and the working parts are of machined bronze and bakelite. The important elements consisting of a $^1/_{15}$ h.p. motor, 200 watt incandescent lamp and base, mirrors, lenses and reflector, are of standard manufacture.

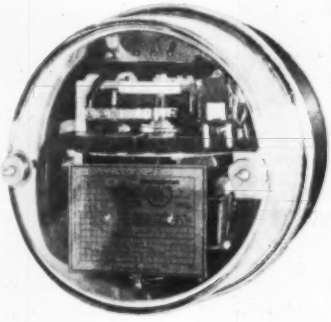
The instrument is designed to aid designers, factory engineers and the more technically trained research men in plant or laboratory, but its uses are as varied and manifold as the different types of machinery built.

The most obvious applications are:

1. Determination of speeds of any periodic motion of rotation, oscillation or reciprocation.
2. Observation and study of the variable movements of cam followers, valve springs and the "float" of pppet valve.
3. The whip of the windings of the armatures of a motor—a generator, or of an aeroplane propeller.
4. The actual value of the torsion.
5. The accurate measurement of the flexion of shafts and crankshafts.
6. Action of the tool on the object in both iron and wood working machinery.
7. Creep and slip of belts.
8. Slip of the induction motor.
9. The checking of the accuracy of Watt hour meters.
10. Inspection of armatures of a machine while in speed.
11. To examine flexible couplings.
12. Mesh and action of gears in action.
13. Disclosing flaws and mechanical errors and defects in design and materials.
14. To show conditions of unbalance and the points and speeds where such unbalance occurs.
15. In the textile industry to show the sewing needles with alarming kinks and bends and just where and how a stitch is dropped; the behavior of the thread swing on bobbins can be studied and intelligently varied to cope with deviation in the speed of spindles.
16. In the printing industry, especially on cloth materials and wall paper the rolls may be registered to the proper relation for the different colors in the design, but when the machine is up to speed the stretch of the material often throws this out of adjustment. The Tackiscope will show this defect while the machine is running, thus avoiding waste of time and materials incident to stopping and starting.
17. If atomized oil or gasoline is viewed through the Tackiscope, it appears as distinct drops flowing slowly enough to study their motion.
18. Bubbles of air injected into flowing water may be viewed through a window in pipe or turbine and its motion observed.
19. The minutest examination of test pieces of sheet metal under vibrational tests for fatigue. The cycle and amplitude of the vibrations being readily determined.
20. The projection of the cycles of motion upon a screen, nighly magnified, is possible with the Tackiscope and the field which this alone opens up is quite apparent.

Improvements in Protective Relays

THE Westinghouse Electric and Manufacturing Company announces several improvements in their Type CO and Type CR relays, which are induction type protective relays for automatically sectionalizing transmission lines and distribution network upon the occurrence of overcurrent or change in direction of the current respectively. They are made in standard models and also in special low energy types for use where only a small quantity of energy is available for the operation of the relays.



Inspection of the relays has been facilitated by making the glass cover and the metal case both removable; the new contacts are more accessible and more conveniently adjusted; and, by means of new universal studs mounting the relays on either slate or steel panels is simplified.

The 4 to 12 and the 4 to 16 ranges have been combined and superseded by styles having a range of 4 to 15 amperes. A smooth adjustment of the current value between 4 and 15 amperes is obtainable.

The operation indicator has been improved in action and operation, and by means of a slight change in the wiring connections, it can be set to operate on tripping currents of either 0.2 or 2 amperes.

All power directional relays are available with directional control which prevents the overload element starting until the directional element contacts are closed in the right direction.

All relays are adjusted to the same curve, a curve embodying the time-tried and approved development of definite minimum time features, a copy of which is etched on the name plate.

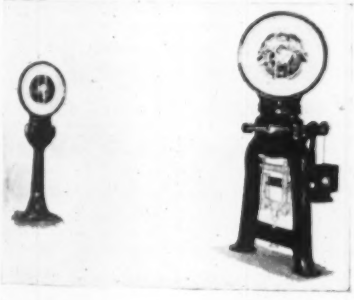
The new relays are strictly interchangeable in the mounting with the old, and the change in appearance is so slight that there is no difficulty in matching up new installation with old.

Dynamometer Auto Gage

(Toledo Precision Devices, Inc.)

DYNAMOMETER tests of automobile and airplane engines are not satisfactory when the engine and the surrounding air remain stationary. In order to make a test to approximate the true conditions, it is desirable to have the dynamometer and engine mounted in a wind tunnel, in which the velocity of the air is approximately the speed of the airplane or automobile.

Various manufacturers are now using wind tunnels in which they test the engines of their automobiles or airplanes. By means of fans and motors, the velocity of the wind in the tunnel may be regulated to meet the requirements, and by means of refrigerating machinery the temperature also may be regulated.



With the Toledo equipment, the dynamometer is mounted on a foundation, and the dynamometer auto-gage is located in a recess in the foundation, but below the dynamometer, and is equipped with remote indication. With the remote indication, which is operated by Selsyn motors—one in the dynamometer auto-gage itself and the other in the remote head—the observer may be located in any convenient position away from the dynamometer itself.

The illustration shows the dynamometer auto-gage, and the remote indication head. The dial on the auto-gage indicates the total torque of the dynamometer. The dynamometer is connected to the auto-gage by a bell crank lever to an arm which extends vertically down from the dynamometer. The Selsyn motor in the auto-gage is driven by a pendulum mechanism and the indicator shaft itself is coupled to the shaft of the Selsyn motor.

The head for remote indication is susbstantially the same as the auto-gage head, with the exception that the pendulum mechanism is left off. The Selsyn motor is mounted in the auto-gage head and the shaft of the Selsyn motor is extended to carry the indicator hand.

When a load is on the dynamometer so as to cause the indicator and motor to move through a certain angle, the Selsyn motor with the indicator shaft on the remote head will move through the same angle and will read the same as the dynamometer auto gage itself.

It is not always necessary to operate the remote indication with a Selsyn motor. Another head, if necessary, may be located at a remote place from the dynamometer itself, and may be operated by means of links or extension levers. The auto-gage may also be located in any convenient spot other than the one described, depending on the construction and surroundings.

The Toledo dynamometer auto-gage with remote indication is entirely automatic in its operation, and is so constructed that it may be conveniently read at any point away from the dynamometer itself. It should be a great aid to automobile and airplane manufacturers throughout the world. The one shown was constructed for a large manufacturer in Germany.

Metallographic Polishing Machine

(*Cincinnati Electrical Tool Co.*)

THE Cincinnati metallographic polishing machine is a sturdy, well built machine throughout. The bowl, disk and ring, together with other small parts, are made of cast bronze, which resists corrosion and thus eliminates the danger of rust particles interfering with the polishing. The depth and diameter of the bowl prevent splashing of the polishing materials and permit it to be easily cleaned. A $\frac{3}{8}$-inch pipe drain prevents stoppage. An outside projecting rim makes it possible for the machine to be fitted securely and permanently into a convenient height work bench. Ball bearings are used throughout.

High polishing speeds and ample power may be had for polishing large specimens for microscopic or visual examination, also for quickly wearing down scratches on specimens of any size. Slow speeds, so necessary for the final polishing and for investigating the nature of non-metallic inclusions, are also available.

This polishing machine is equipped with a variable speed motor that gives a range of speeds between 300 and 3000 RPM. A convenient lever attached to the brushes of the alternating current motor enables the speed to be varied readily while the speed of the direct current motor is regulated by field and armature-control rheostats.

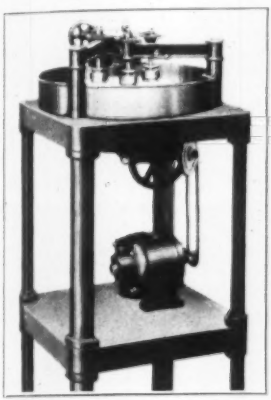
This polishing machine is easy to operate. A simple clutch arrangement enables the operator to change polishing disks quickly and easily by merely lifting one disk from the motor shaft and substituting another. A spun copper cover is furnished for the bowl when not in use, thus preventing contamination from dust in the air.

New Metallographic Polishing Machine

(*American Instrument Co.*)

THE new Aminco automatic metallographic polishing machine has a polishing head covered with a suitable polishing cloth. This head is mounted on vertical spindles, running in ball bearings, and is driven by a belt from a motor.

Resting on the polishing disk may be seen 3 specimens in their brass ring holders. These holders float on the polishing cloth and change their positions slightly as the contour of the cloth changes. The specimens are held lightly against the cloth by spring rods which mesh with an eccentric gear. This eccentric gear gives the motion to the specimens which so largely contributes to the perfect work done by the machine. It is accomplished as follows:



The eccentric gear is driven through a speed reducer and as it rotates it causes the 3 specimen holder gears also to rotate. Being meshed with an eccentric gear, the 3 specimen holder gears not only rotate on their own axes, but they continually oscillate toward and away from the center of the polishing disk. Thus the specimen has the following motion:

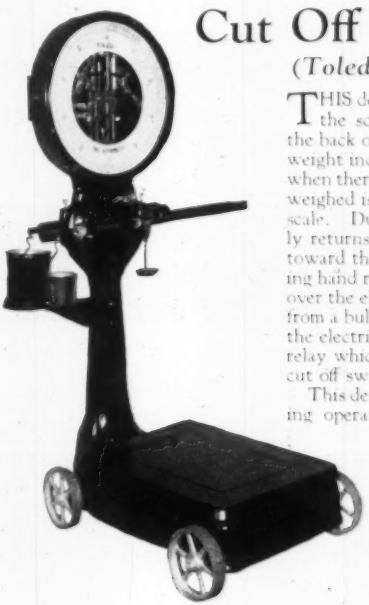
It is free to move vertically within limits. It rotates on its own axis. It is slowly moved from the outer edge to the center of the polishing disk and the result of this motion is a perfectly polished specimen.

The new automatic metallographic polishing machine eliminates the personal equation and produces a high grade of work. It will very quickly save many times its cost in any metallurgical laboratory.

This machine will polish 3 different specimens at one time. The specimens need not even be of the same metal, providing they fall into such a classification that they can be polished with the same material, and on the same cloth.

Cut Off Weighing Device

(*Toledo Precison Devices, Inc.*)



THIS device has 2 dials, on the front and back side of the scale head. The cut off indicating hand, on the back of the head is set to the desired weight. The weight indicator on the front of the head stands at zero when there is no load on the scale. The substance to be weighed is then allowed to flow into a container on the scale. During this process the cut off indicator gradually returns to zero, and the weight indicator advances toward the desired weight. When the cut off indicating hand reaches zero it covers the slot which is located over the electric eye. This cuts the light which comes from a bulb placed over the slot, and this in turn causes the electric eye to make a contact which travels to the relay which operates the solenoid valve, or any similar cut off switch.

This device is applicable to any predetermined weighing operation in oil refineries, flour and feed mills, bakeries, food product manufacturing, concrete mixing cement mills, and in fact, in any industry where definite quantities of a product are repeatedly weighed.

The electric cut off weighing device insures exact weight, is automatically operated and may be attached to any form of endless conveyor, continuous filler, or mass production packaging machine.

Two New Control Valves

(Bailey Meter Company)

THE new boiler feed pump governor illustrated in Fig. 1 is designed primarily for use with turbine driven pumps. Its purpose is to maintain a constant differential between the pressure of steam leaving the boiler and the pressure of feed water in the feed water lines. The governor is installed in the steam line to the turbine and controls the differential pressure by throttling the steam supply.

Feed water pressure is transmitted to the inside of the sylphon G, this force being balanced by the steam pressure and the spring K on the outside of the sylphon. When the steam pressure decreases, the sylphon expands moving the valve mechanism upward, thus throttling the supply of steam to the turbine. In a similar manner more steam is admitted to the turbine when the steam pressure rises. To bypass the governor, valve A is closed and valve B is opened, thus equalizing the pressure on the inside and outside of the sylphon so that the spring will hold the valve in its open position.

The governor may be set for any desired differential by adjusting the spring tension by means of screw N. There are no glands or stuffing boxes on the valve rod so that its motion is not retarded and there is no tendency for the valve to leak.

The valve is of the tight seating and fully balanced design and the entire seating arrangement can be easily installed or removed from the valve body without taking the body from the line.

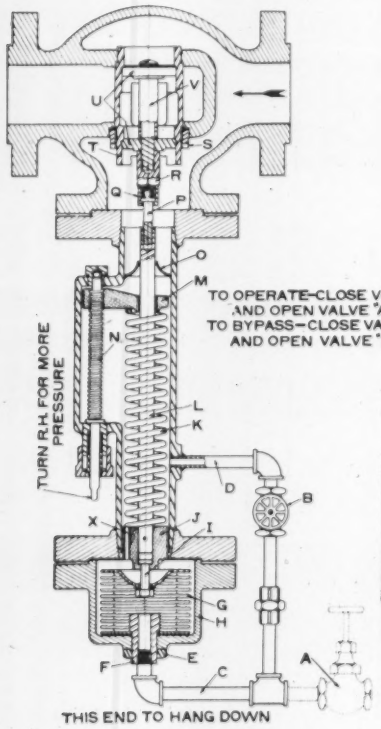

TO OPERATE—CLOSE VALVE "B" AND OPEN VALVE "A"
TO BYPASS—CLOSE VALVE "A" AND OPEN VALVE "B"
TURN R.H. FOR MORE PRESSURE
THIS END TO HANG DOWN

Fig. 1

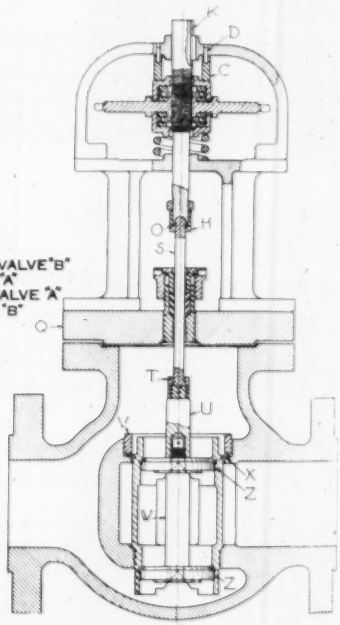


Fig. 2

The new control valve, Style K, illustrated in Fig. 2, is for use with Bailey automatic control systems and can be used with practically any fluid. The V-ports are scientifically designed to give a straight line flow characteristic. A fully balanced valve with the valve cage and discs removable are other distinctive features of the valve.

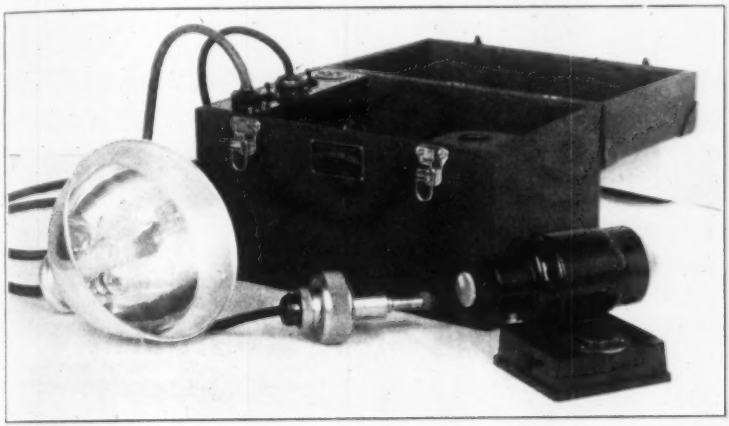
New Model 3 Vibroscope

(Electrocon Corp.)

THE Vibroscope operates on the well known stroboscopic principle, depending upon interrupting the vision between the observer's eye and the mechanism under observation so that he gets a quick glimpse of the mechanism each time it reaches a certain point in its cycle.

The parts of the Model 3 Vibroscope are:

The *hand lamp* consists of an aluminium reflector 8½" diameter which houses 3 neon tubes. It is shaped at the back so that it may be comfortably gripped in the hand, and also has a leg so that it may be laid down on a flat surface with its rays directed at a moving object. The neon tubes produce flashes which combine brilliance with extremely short duration, the glowing element consisting of a long spiral of glass tube. They are mounted on standard screw bases and are of very strong construction. The tubes will not burn out.



The *breaker head* is driven from the mechanism under observation and is provided with rubber and steel driving points exactly the same as a hand tachometer, and no more power is required to drive it than a tachometer. Its body is of brass, and its $\frac{3}{16}$" diameter steel shaft is carried on ball bearings, which do not require lubrication or adjustment. An electrical circuit is broken once per revolution at a pair of cam operated platinum points, which are reached for cleaning or adjustment by removing a cover plate. A small knurled knob in the breaker head is known as the phase adjuster, and by turning this the neon tubes can be made to flash at different positions in the revolution, so that the moving mechanism may be viewed at different positions in its cycle. If the phase adjuster is turned clockwise, the mechanism under observation will appear to turn clockwise, and vice versa. The phase adjuster is graduated in degrees so that phase positions can be definitely identified, such as the exact point in the revolution at which a valve in an automobile engine is observed to commence opening under the rays of the neon lamp.

The *carrying case* contains 3 or 4 dry cells which provide all the power for operating the neon tubes, the hand lamp and breaker head. At one end of the case is a container which carries the necessary coils for stepping up the battery voltage to operate the neon tubes. This container may be removed if it is desired to operate the instrument from a storage battery instead of the dry cells. Mounted on the coil container is a knurled adjusting knob, known as the definition control. For general applications the clearness with which details stand out on moving parts is sufficient when the neon tubes are flashing at maximum brilliance, but it sometimes happens that the very minutest detail is required to be observed. The definition control is then used, and as it is slowly turned the moving parts will appear in greater detail, with a corresponding slight sacrifice in the brilliance of illumination. When the limit of definition is reached it will be every bit as clear as if the moving object were actually standing stationary, and the illumination will still be good.

The *motor unit* can be supplied in place of the breaker head and is for use where it is more convenient to regulate the light flashes from some source which is in no way connected with

the mechanism under observation. It is shown on the right of the illustration and consists of a small motor which will run from either direct or alternating current supply. At one end of it is mounted a contact breaking mechanism which is identical to that contained in the breaker head, and at the other end a governor mechanism is mounted, which will hold the motor perfectly to any desired speed. A knurled knob projecting from the governor end serves to regulate the speed to an extremely fine degree of accuracy, and this is supplemented by a rheostat knob mounted in front of the motor, which is only used at low speeds. The accurately governed range of the motor unit is from 700 to 7000 r. p. m. But speeds much higher than this can be observed with it, since it can be run at any low multiple of the shaft speed under observation. Projecting from the breaker end of the motor unit is a short length of shaft to accommodate a tachometer.

The Vibroscope is applicable to the study of rotary, reciprocating, or vibratory motions. In fact, to any type of motion provided that it occurs in repeating cycles, and provided that the hand lamp flashes in synchronism with the motion, or at a low multiple of it. Taking the simple case of an automobile engine, if the breaker head is driven at crankshaft speed, all motions at that speed can be studied, but valve gear and motions at camshaft speed cannot be studied. But if it is driven at camshaft speed then all motions at either camshaft or crankshaft speed can be studied. Motions where a certain movement happens just once and does not repeat, cannot be studied with the Vibroscope.

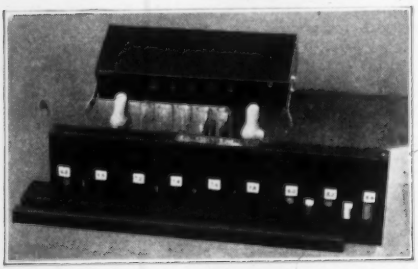
At speeds above 1000 r. p. m., the light flashes are sufficiently frequent to appear continuous, while at about 300 r. p. m., although not appearing continuous, observations can be made with comfort in a normally lighted shop. For lower speeds it is usually best to screen off some of the surrounding light, and by doing this, successful observations have been made at speeds as low as 40 r. p. m. The highest speed at which the breaker head can be run is about 12,000 r. p. m., but higher speeds than this can be observed by using the motor unit and running at a low multiple of the speed.

The New pH Slide Comparator

(W. A. Taylor & Co., Inc.)

THE slide comparator consists of 2 principal parts, the slide and the base. The slide is a Bakelite case 10" long, $2\frac{3}{4}$" high and $\frac{5}{8}$" thick. It contains 17 vertical holes and 17 horizontal slots which pass through the exact centers of the holes. In these holes are placed the 9 color standards for any given indicator and 8 ampoules of distilled water. All these ampoules are held in place by a lid which is screwed on the top of the slide.

The base consists of 2 parts. The lower part contains a slot in which the slide may be moved back and forth, 2 holes containing vials of indicator solution, 5 holes containing test tubes, and a closed compartment for a ground glass plate. Vertical slots run through the 3 central holes in the base holding the test tubes, these slots corresponding exactly with any 3 of the slots in the slide. The ground glass is contained in a closed compartment directly behind the 3 slots in the base. The upper part of the base serves as a cover for the vials and test tubes when the set is not in use. It is fastened to the lower part by means of spring catches.



In making determinations, the top is removed from the base, 3 of the test tubes are filled to the mark (5 cc.) with the sample to be tested and placed in the 3 holes back of the slots in the base. To the central tube 0.5 cc. of the indicator solution is added by means of the pipette and nipple and the contents are thoroughly mixed. The slide containing the color standards is now placed in position on the base and, holding the instrument toward a window or other source of daylight, the slide is moved back and forth in front of the test samples until a color match is obtained. The pH is then read off directly from the values on the front of the slide.

Being molded from Bakelite the slide comparator is unaffected by water, acids or alkalis. It therefore will not warp or come apart. Molding also gives it a machined precision that is impossible with wood or sheet metal.

Since the color standards are enclosed in a Bakelite case, there are no loose standards to be inserted and removed in making pH determinations. Thus all chance of loss or breakage from handling individual standards is eliminated. All color standards and test tubes are 11.5 mm. outside diameter. This small equipment makes the set small and compact and therefore readily portable. Of far greater practical importance, however, is the fact that the resulting thinness of layer of material being tested enables one to make accurate determinations on far more highly colored and turbid materials, without dilution, than is possible with larger tubes.

The fact that determinations are made simply by sliding the color standards in front of the test sample until a color match is obtained makes the operation of the set extremely simple so that it is possible to teach a workman to use the set accurately with a few minutes' instruction.

Slide Comparators are supplied to cover the pH range 0.2-13.6. Each comparator covers a range of 1.6 pH units, the standards being in intervals of 0.2 pH.

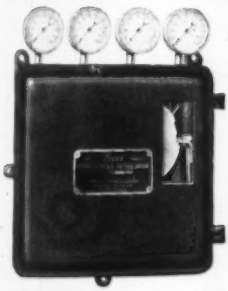
Long Range Slide Comparator—The long range slide comparator was designed to meet the need of those workers who require a portable set covering a wide pH range. This set is made in 5 models (T-3, T-4, T-5, T-6 and T-7) to cover the range of any 3, 4, 5, 6 and 7 indicators respectively between the limits of pH 0.2 and 13.6, the number after T indicating the number of indicators included in the set.

Each long range slide comparator contains one complete slide comparator; 2 to 6 extra color standard slides; vials of the corresponding indicator solutions, with pipettes and nipples; and a supply of 5 cc. test tubes. This equipment is contained in a portable case 11" long, 9½" wide and 4½" high.

New Time-Cycle Regulator

(*Taylor Instrument Companies*)

THE operation of this instrument is independent of temperature or pressure but can be used to operate in conjunction with either condition. In general its use extends to wherever it is desirable to control the duration of operations in prescribed sequence, where such operations can be started and stopped by means of an electrical or fluid operated device.



This type of instrument consists of an electrically driven cam which as it revolves, progressively opens or closes small pilot valves. These valves in turn regulate the supply of compressed air to diaphragm valves, electro pneumatic switches, or other pneumatically operated devices as may be necessary according to the requirements of the individual applications.

The cam is mounted on a cam shaft which rotates in ball bearings. Steps are cut on the cam corresponding to the number of pilot air valves to be operated. Practically any total revolution of cam can be supplied. Cam speed can be increased or decreased to meet new requirements of the process by substituting new cams and gears and this change-over can easily be accomplished by the user.

New 350 Power Microscope

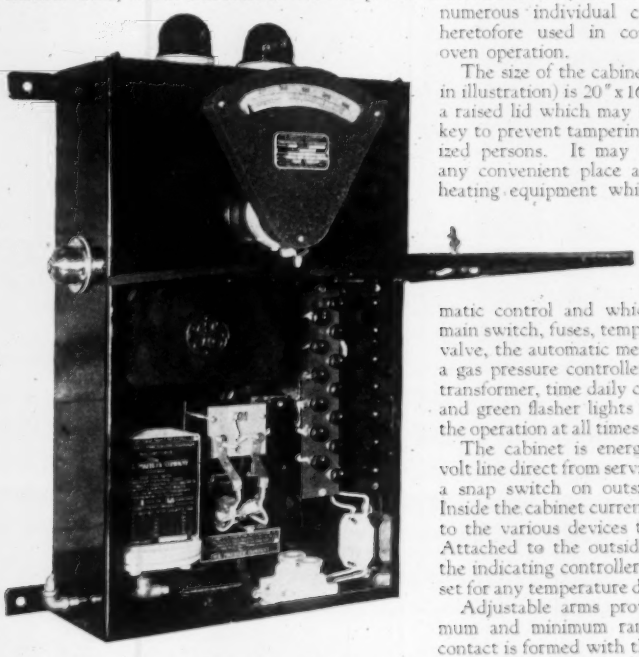
(*Wollensak Optical Co.*)

THIS Microscope affords magnification from 100 to 350 power accurately graduated in steps of 50 power. It has a concave mirror, rack and pinion, and a tilting stand which enables the microscope to be used in all positions. A detachable base simplifies the examination of any matter that cannot be placed on a stage conveniently.

Automatic Temperature and Safety Control for Ovens

ONE of the difficulties experienced by manufacturers and users of industrial ovens for baking, japanning and drying, has been to secure positive temperature control and thus provide uniform baking conditions at all times. Such control, however, is absolutely necessary if a high standard of finish and efficiency is to be attained.

To meet this condition, The Paul Maehler Company developed the Maehler Electrical Control Unit, which embodies in one compact and automatic unit, the functions of their numerous individual control devices heretofore used in connection with oven operation.



The size of the cabinet (shown open in illustration) is 20"x16"x5", utilizing a raised lid which may be locked with key to prevent tampering by unauthorized persons. It may be installed at any convenient place adjacent to the heating equipment which it controls.

In the cabinet are assembled the various devices providing automatic control and which include the main switch, fuses, temperature control valve, the automatic mercury actuator, a gas pressure controller, high voltage transformer, time daily control, and red and green flasher lights which indicate the operation at all times.

The cabinet is energized by a 110 volt line direct from service line through a snap switch on outside of cabinet. Inside the cabinet current is distributed to the various devices through a jack. Attached to the outside of cabinet is the indicating controller which may be set for any temperature desired.

Adjustable arms provide the maximum and minimum range and when contact is formed with the temperature indicating arm, the electrically operated temperature control valve closes or opens automatically as the case may be, thus retarding or increasing the fuel supply to the oven and maintaining oven temperature within the desired range.

On the heater itself is located a Maehler-Maxon automatic shut-off safety valve, which in event of either fan or fuel failure automatically shuts off the fuel supply. When once closed this valve cannot be turned on except by manual operation, thus providing safety as an additional safeguard; however, an automatic Time Delay Control located in the cabinet under lock and key prevents any further flow of fuel until a certain predetermined time has elapsed, which may be set at any length from one second to thirty-three minutes.

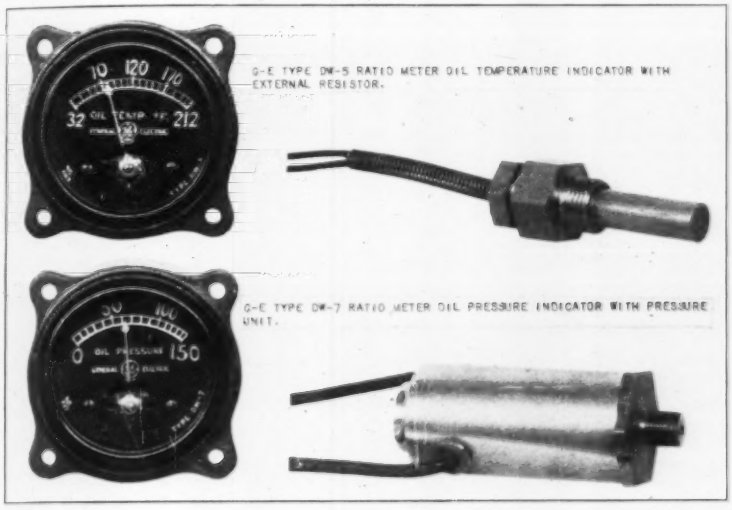
The mercury actuator in the cabinet operates an electric match, or spark plug, at the pilot light and provides intermittent sparking of five seconds duration and five seconds off. Thus, even if the pilot light should go out, it is instantly relighted by the spark plug. This is wired through the red flasher light on top of the cabinet which shows at a glance that the spark plug is operating. The time delay relay is wired through the green light on top of the cabinet so when safety valve is closed, due to any interruption, the green light is on, thus indicating to the operator by signal, the exact functioning of the control at all times.

The entire electrical input to the control unit is but 175 watts, and but 75 watts per hour are used continuously; the balance of 100 watts being momentary at the time of electric spark and temperature control operating.

New Aircraft Indicating Instruments

(General Electric Co.)

THE new instruments are built in cases which conform to standard Army-Navy specifications. The temperature and pressure elements are separate units; those for oil temperature, oil pressure, fuel pressure and cooling liquid temperature are designed to be attached to the standard fittings, replacing the conventional temperature bulbs and pressure tubing. The elements for the air temperature indicators are arranged for mounting on any convenient part of the aircraft. These air temperature indicators are used for ice warning and wherever similar temperature indicators are desired.


G-E TYPE DW-5 RATIO METER OIL TEMPERATURE INDICATOR WITH EXTERNAL RESISTOR.
G-E TYPE DW-7 RATIO METER OIL PRESSURE INDICATOR WITH PRESSURE UNIT.

All the indicators operate on the principle of current flow in a resistance bridge circuit. The current in a variable resistance is compared with that in a fixed resistance, the latter being part of the indicating instrument and the variable resistance being in the separate element. The resistance of the temperature element changes with temperature and that of the pressure element changes with pressure. But a small amount of current is required (approximately 50 milliamperes normally), the supply being a 12-volt battery or equivalent. The accuracy of the instruments is not affected by variations in battery voltage.

All the instruments are furnished with shock-absorbing cases which conform to Army-Navy specifications, and permit flush mounting on instrument panels. The inside cases and operating mechanism float in sponge rubber carried by the outer cases. The outer cases protect the operating mechanisms from mechanical injury and act as magnetic shields to reduce interference with card compasses which may be located nearby.

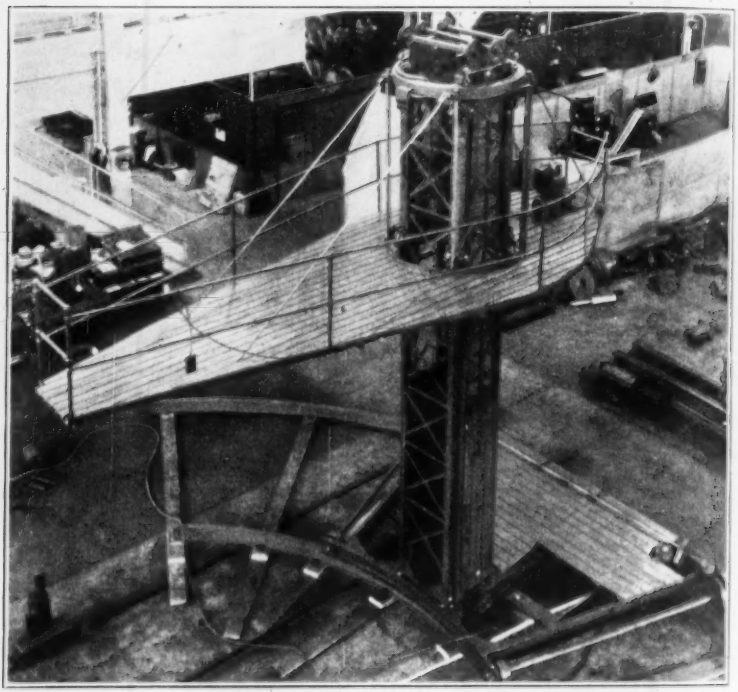
The instruments are accurately designed and carefully constructed to withstand severe vibration. All bearings are jeweled and luminous pointers and scales are provided.

The temperature elements are resistances, sensitive to temperature. Their electrical resistance changes in accordance with the temperature to which they are subjected. For oil temperature and cooling liquid temperature the elements consist of hermetically sealed metal cartridges threaded at one end for attaching to the standard fittings on engines or radiators. Inside the cartridges are the temperature-sensitive resistance coils and connections are brought out for wiring to the indicating instruments. For ice warning and air temperature the elements are designed for maximum sensitivity with minimum drag. They are intended for mounting on struts, wings or fuselage members.

The pressure elements consist of variable resistances actuated by a copper bellows, totally enclosed in weatherproof, oil-tight, metallic cartridges. They are threaded for attaching to the standard engine and fuel-line fittings. The oil (if oil pressure) or the fuel (if fuel pressure) enters the open end of each bellows causing it to expand in proportion to the pressure. This expansion changes the electrical resistance of the coil. Connections are brought out for wiring to the indicating instruments.

Advantages of the line: (1) simplicity of remote indication, and elimination of tubing and mechanical connections; (2) light weight of relatively long-distance installations; (3) high accuracy and the ability to withstand vibration, and (4) the use of one indicating instrument to measure any number of corresponding temperatures or pressures successively by means of a selector switch.

Astronomical Observer's Platform



FROM the River Works of the General Electric Company at West Lynn there was recently shipped a piece of astronomical equipment which is the first of its kind in the world. It is an observer's platform which revolves in any desired direction, enabling a person making observations with an astronomical telescope to follow the telescope in its rotation.

The platform was built for Harvard Observatory, at the suggestion of Dr. Harlow Shapley, director of that observatory. It is to be installed at the Boyden Station of the Harvard Observatory, located at Bloomfontein, South Africa. It will make the journey to its permanent location by boat from Boston.

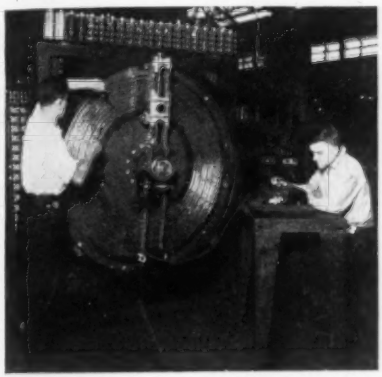
Designed by John French, designing engineer for the General Electric plant, the equipment consists of a traveling carriage, which moves upon circular rails, supporting a tower which in turn supports a gallery. The gallery can be raised or lowered, or turned in a horizontal direction around the tower. This motion, combined with that of the lower carriage, enables an observer to place himself in any desired position in order to look through the eye-piece of the telescope. This is essential as all such telescopes are continually in motion, following the course of any particular star.

The platform is operated by electric motors, the control buttons being convenient to the observer's hand on the platform. The platform will be used at the South Africa station with a 60″ telescope.

Automatic Controls for Adjusting Rolls in Steel Mills

SIX automatic screwdown controls for providing proper adjustment of the rolls in a rolling mill have been manufactured recently by the Westinghouse Electric and Manufacturing Company, for installation in a steel mill in Chicago.

In rolling steel through a mill, the ingots naturally become smaller at each passage through the rolls, and, consequently, the rolls must be brought closer together. Formerly it was necessary to have an operator make the adjustments manually after each passage of the ingot through the rolls; but, with the automatic control, a predetermined amount of "screw-down" or reduction of the distance between the rolls is arranged for by plugging in leads at certain points and, when the mill is in operation, this screw-down is provided automatically at the correct intervals.



Using this apparatus, one man can operate the entire mill. When the work is ready to begin, he simply throws a pass master switch, which starts the screws turning for proper adjustment for the first pass. Sights indicate when everything is ready. After the beam of iron or steel has passed through the mill, the operator moves the pass master switch to the second position—and so on. By throwing the switch to the off position the operator may resort to manual control at any time.

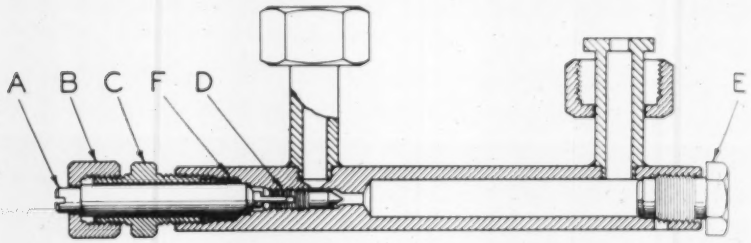
The illustration shows one of the automatic screw-down controls on test in the East Pittsburgh Works of the Westinghouse Electric and Manufacturing Company. This view is from the front and indicates the number of contacts: there are more than 230 of them through which the operation is controlled.

As the screw-holder (shown in a vertical position in the photograph) is rotated, its sliding contact meets the spirally-mounted contacts on the stationary Micarta panel, energizing the circuits that provide the correct spacing between the rolls of the mill.

The automatic screw-down is an example of eliminating the uncertain human element from industry and assuring the unvarying precision and uniformity required. It has proved that it can very successfully take care of that task in operating the mill to which it has been assigned; and it may be an indication that the operation of entirely automatic steel mills is a future possibility.

New Damping U-Tube

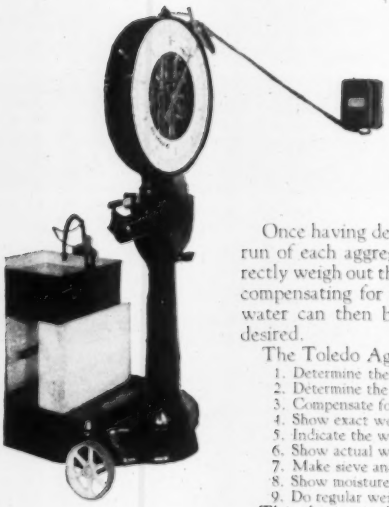
A NEW damping U-tube has been perfected recently by the Foxboro Company for use on all their new style flow meters and flow controllers. This U-tube can be adjusted for proper damping while the instrument is in operation. There is no need of shutting the pressure off or taking the instrument apart in order to make this adjustment.



At A is a "screw-driver" which is fitted to the end of needle valve D. By turning A, adjustments can be made in the damping without the mercury being forced out. These adjustments can be made very minute or very large as conditions warrant.

Aggregate Auto Gage

(Toledo Precision Devices, Inc.)



WITH modern methods, and under actual job conditions, the strength of concrete is largely determined by the amount of mixing water used per sack of cement. As mixes are always based on dry aggregates, and all have a certain percentage of moisture, it is necessary to determine the exact amount of water to use, and so the moisture content of the aggregates must be ascertained and accounted for.

Once having determined the moisture content of the regular run of each aggregate, this device will automatically and correctly weigh out the specified amounts of the various aggregates, compensating for the surface moisture in each. Cement and water can then be added by weight in right proportion, if desired.

The Toledo Aggregate Auto Gage will:

1. Determine the specific gravity of concrete aggregates.
2. Determine the percent of moisture of concrete aggregates.
3. Compensate for surface moisture of concrete aggregates.
4. Show exact weight of dry aggregates.
5. Indicate the weight of regular run aggregates.
6. Show actual weight of surface moisture.
7. Make sieve analysis.
8. Show moisture within the aggregates themselves.
9. Do regular weighing.

This device is designed primarily for production, laboratory and inspection work. It insures correct water-cement ratio, correct proportion of cement to volume of concrete, uniformity of product, strength and durability. The aggregate auto gage reduces waste, reduces the total cost of material, facilitates handling and placing, and it simplifies inspection and increases production volume.

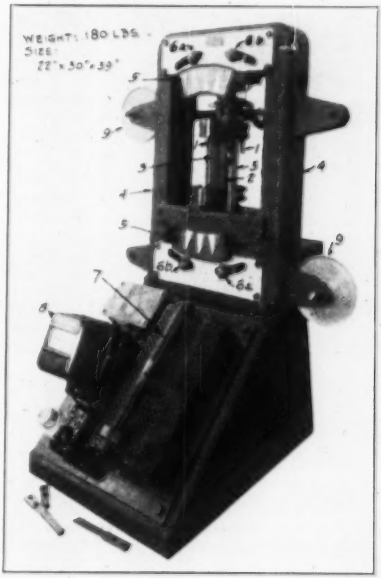
Foeppl-Heydekampf Bending Machine for Static and Repeated Reversed Loads

(Southwark Foundry & Machine Co.)

KNOWLEDGE of the endurance properties of all machine parts subjected to repeated stresses, is very important. Consequently endurance or fatigue tests become more and more essential. An ideal fatigue machine should permit the different "short time" determinations of the fatigue limit to be made. This limit is defined as that stress that can be withstood for an indefinite number of stress cycles without fracture of the specimen.

The frame of the machine (4) is a light alloy casting into the lower part of which is built a switch panel containing all necessary operating and controlling instruments.

The bottom of the specimen (1) is rigidly clamped to the frame (4) and the top is connected with an oscillating mass (2) of considerable length. Usually the tests are run with two specimens at a time (one is shown already broken and the lower part of it removed from the frame). The machine may, however, be used equally well for a single specimen. Two thin flat springs (3) are mounted in a similar way between frame (4) and oscillating mass (2), but they are not intended to break, being thinner than the specimens. The springs (3), the specimens (1) and the mass (2) form a mechanical swinging system, which is excited by two pairs of electromagnets (6a) and (6b), alternately giving impulses to the mass (2). The magnets are switched on and off by a special lever contact device, not visible in the illustration. The switch lever is moved by the mass (2), due to friction, so that the number of impulses agrees with the natural frequency of the oscillating system. The exciting magnetic forces change their direction in the end position of the swing. Once slightly touched by hand, the system starts and keeps on swinging "in resonance" and requires very low power (not over 0.3 KW). The amplitude of the oscillation is varied by changing the current in the electro-magnets (6) by adjusting the rheostat (7).



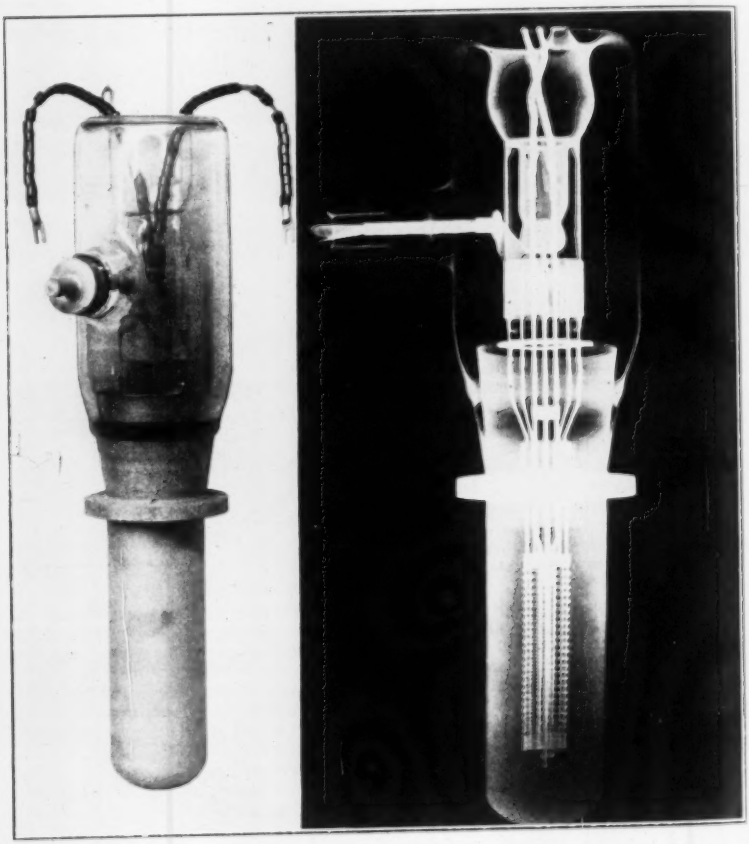
The oscillation is a rotary reciprocating movement of the mass about an axis through the middle of the specimen. The angular amplitude can be read from special visual reading devices (5) attached to the ends of the mass (2). Both devices give the same reading, checking each other. The stress in the specimens is proportional to the amplitude within the range of Hooke's law. It can be directly figured from the readings on device (5). If Hooke's law is exceeded, the exact determination of the stress must be made by an additional static loading arrangement furnished with the machine. The pulleys (9) and some other weighing and measuring equipment not shown in the figure permit finding the actual stress strain relation, thus eliminating the usual error, due to figuring the stress according to Hooke's law. This static weighing device also eliminates the errors based on the assumption that the clamps are rigid, since the amount of yield in the grips is measured in the static test.

The outstanding feature of the machine is that the stress is constant over the full gage length of the specimen. The acceleration forces during the oscillation are pure moments. The center of mass of all moving parts is in a stationary position, so that a pair of accelerating forces is always generated. The stress distribution over the length is as uniform as the one in tensile specimens and the simple shape of the latter without reduced sections or tapers is readily applicable for fatigue tests on this machine. The failures are, therefore, not restricted to a certain part of the specimen, but occur where the weakest point of the material happens to be, thus clearly revealing any lack of uniformity of the material tested. The uniform stress distribution is also applied in the static bending test.

The number of cycles is counted by an electrical counter (8) driven by a small synchronous motor in series with the pulsating current line feeding the electromagnets. As a matter of fact, the number of electric impulses is counted, which, however, is equal to the number of oscillations or stress cycles, due to the resonance principle applied. There is, furthermore, an automatic adjustable contact mechanism, which stops the machine after a failure.

It should be noted that the specimens do not rotate and have an unusually large part of their total volume subjected to the testing stress. The machine is, therefore, particularly convenient for any of the proposed "short time" tests, e.g. rise of temperature method or electrical resistance method. It also permits with more than the ordinary facility the study of the mechanical hysteresis effect to which property the names "damping capacity" or "dynamic ductility" have also been applied.

The machine represents a very progressive type of fatigue equipment and materially simplifies the application of dynamic stresses.



Seeing the Invisible

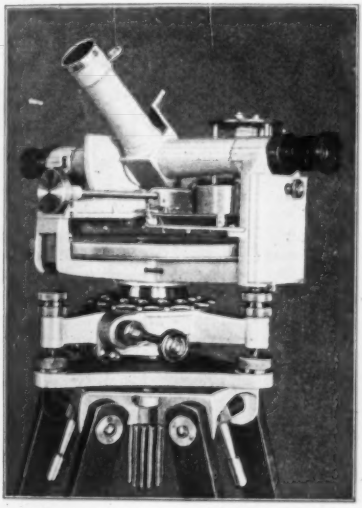
This intimate picture of the internal organism of the high-power, short-wave radio tube (FT6 Pliotron) is an excellent example of the industrial use of X-rays. The X-ray photograph of the tube, a product of the General Electric research laboratory, is made when the tube is completely assembled and before the costly process of air evacuation has been started. Imperfections in the delicate, lace like structure within the copper anode of the tube are immediately detected in the X-ray photograph. A second photograph is made before shipment, to make sure the tube is perfect. The pliotron as seen by the eye is shown in the other picture.

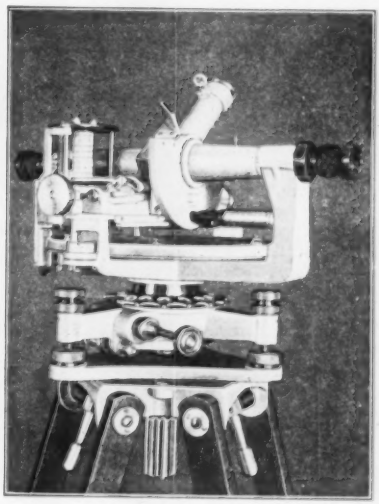
New Recording Balloon Theodolite

(*Gustav Heyde*)

THE observation of the force and direction of the wind is of utmost importance for meteorological as well as aerotechnical purposes, and the usual method of ascertaining these elements consists in employing so-called pilot balloons capable of disclosing a regular climbing capacity which may be controlled at will and amount to about 120 m., 150 m. or 200 m. per minute. When such pilot balloons are released and observed by a theodolite as to horizontal direction and elevation, horizontal and vertical curves indicating the movements of the balloon can be prepared to serve as data for meteorologists and aeronautical experts.

As a rule, observations are made by means of two types of balloon theodolites: plain and recording ones. The former may be handled even by technically untrained assistants and are adapted for all measurements requiring no greater accuracy than about 1/10° and being carried out every minute or so. If greater accuracy and more rapid observations are necessary a recording balloon theodolite of the type described below, must be employed.





Principles of Construction. In order to be universally useful the instrument had to comply with the following requirements:

1) reliable and rapid erection,
2) omission of superfluous weights,
3) compact design,
4) dust-tight construction of all finer parts,
5) easy and safe operation.

Connections involving photographic recording were therefore dispensed with, and in lieu thereof a remarkably simple recording device for position and time was designed and the arrangement and reading of the circles were chosen so that horizontal and vertical direction takes place in one eyepiece wherein also the adjustment to the object is effected, i.e. not in an auxiliary telescope. For particularly exact and quick work a second eyepiece is provided opposite the first one by means of which the object can be followed while the first observer takes the readings. The results of the measurements recorded as direction values on the time drum on millimeter paper and on the horizontal drawing surface on polar coordinate paper are available immediately after observation, while films must first be developed and the observations are lost if anything goes wrong with the photographic part.

In response to practical demands the lenses are chosen so as to provide for a magnification of 18× with a field of vision of 2¼°. The focal length of the telescopic objective is 450 mm. and that of the orthoscopic eyepiece; 25 mm.

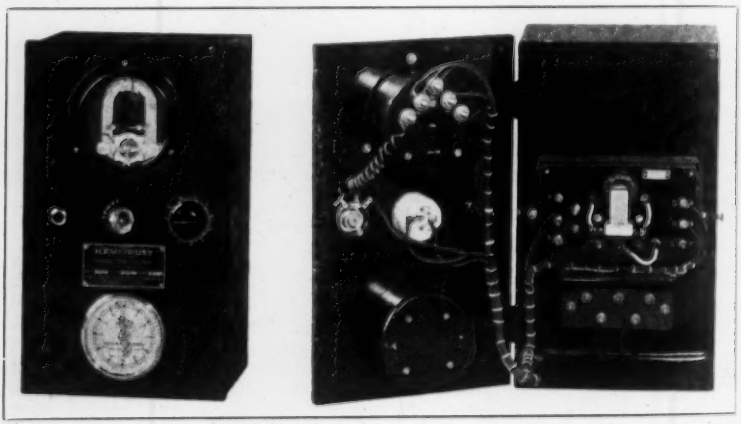
The design avoids structural parts which, as in other types of theodolites, project a considerable distance from the closed form and thus become troublesome. Telescope circles and elevating screws, which in theodolites of other type would cause inaccuracies or failures if the instrument were exposed to wind and weather, are covered and arranged dust-tight. The instrument can be set up by untrained people after some practice. The stand is fitted with a novel lever clamping device to avoid thumb nuts and screws. Set screws for following the object in horizontal and vertical direction are disposed on both sides and made so that the large knobs arranged on flexible shafts can be handled also with gloves. Circular divisions are carried out by specially constructed dividing engines and allow an estimate of one minute for both horizontal and vertical circles.

Automatic Excess Temperature Cutout

(Hevi Duty Electric Co.)

THE automatic excess temperature cutout can be applied to any type of furnace to guard work or furnace from damage due to overheating.

It has been the practice to employ an excess temperature fuse or link in the furnace control system which was intended to melt in case the furnace exceeded safe temperatures. Due to the shortcomings of this method, brought about the development of the automatic excess temperature cutout.



The instrument responds to a thermocouple located in the furnace chamber which actuates a thermal cutout to control a relay which is a part of the furnace control system. Adjustable controls are provided so that the instrument can be set for any desired temperature. It can be calibrated for any thermocouple and used for protection purposes up to 3000° F. In case the furnace temperature rises to the set point, contact is made and the heating source interrupted. Warning is provided also, against failure of the thermocouple operating this instrument.

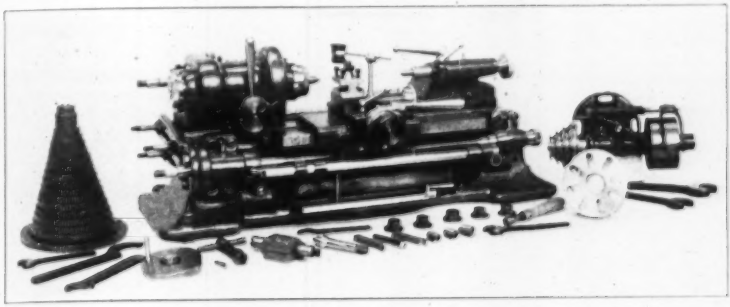
When the relay is actuated, the heating source is shut off and a light indicates or an alarm bell may be rung to attract the attention of the operator.

Precision Threading Lathe

(R. Y. Ferner Co.)

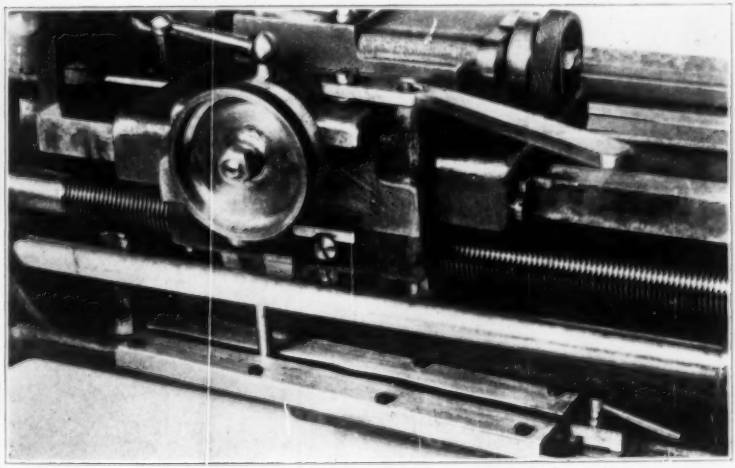
FOR several years the Société Genevoise d'Instruments de Physique, of Geneva, Switzerland has marketed five sizes of special screw cutting lathes, up to a capacity of 48 inches between centers. The company has recently redesigned the smallest of these lathes which will be known as Type PF-2A.

This lathe now has a bored spindle permitting the use of spring collets and the machining of long thin pieces, as well as working the larger pieces on a revolving center. It is also provided with a slotted face plate permitting internal threading also. Other improvements of the lathe include better lubrication of all the bearings.



This lathe uses change gear wheels for obtaining different pitches. A set of these is furnished with the lathe making it possible to obtain 36 pitches in inch units between 4.5 and 100 threads per inch as well as 37 metric pitches from 0.1 mm to 5.0 mm. The accuracy of the threads obtained is guaranteed to 0.0001 inch for the whole length of range of the machine, 8 inches.

The lathe has a maximum distance between centers of $8^{5}/_{8}$ inches and will cut external threads up to 2 inches diameter. The maximum diameter of a workpiece over the ways can be 6 11/16 inches, or, over the carriage, $4^{3}/_{4}$ inches.



The lead screw of the lathe is automatically compensated for any small errors in it by use of an arm extending from the nut to a curved slot, the curvature of which is determined from accurate measurements of the errors of the screw. The slight additional rotation or retardation of the nut at any point serves to hold the cutting tool at all times in the correct position for the standard temperature of 68° F. The plate carrying this slot can also be rotated about

an axis to make correction for temperature so as to cut screws to be standard at any temperature between 32° and 68° F.

The slotted face plate, furnished with the lathe to provide for the cutting of internal threads is 4¾ inches in diameter and allows threading of pieces up to 3 3/16 inches external diameter.

The lathe is driven through a 4-pulley countershaft and a 5/16 inch round belt to the driving pulleys of the lathe, giving the four work speeds of 26, 46, 78 and 140 r. p. m. The return speeds are three times these.

The toolholder is adjustable in two directions, square to each other, by means of two micrometer screws reading to .0004 inch. In order to disengage the cutting tool at the end of the cut the upper slide can be rapidly pulled back by a lever and then be brought back to its previous working position without it being necessary to vary the adjustment of the micrometer screw that determines the depth of cut. This speeds up the work and avoids useless wear of the micrometer screws.

The tailstock is also adjustable so as to obtain truly cylindrical work. The headstock is fitted with a reversing gearing and clutch coupling, and a connecting rod with adjustable stop pieces controls this clutch coupling to automatically stop the lathe at the end of travel in each direction to avoid any possible damage that might arise from inattention of the operator.

Spring collets of an external diameter of 9/16 inch are supplied in sizes varying by 0.02 inch from 0.02 inch to 0.05 inch, or special collets can be supplied when called for. The driving plate for external threading is 4 inches in diameter. Other equipment of the lathe includes a tool holder for internal threading, a bored draw-in bar a set of female centers, a magnifying lens with support, and two sharpened cutting tools of 60° and 55° angle.

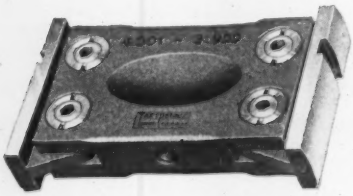
The overall length of the lathe is 31 1/4 inches, its width 15 1/8 inches, its height 13 3/16 inches, the height of the spindle over the bottom of the bed 9 5/8 inches.

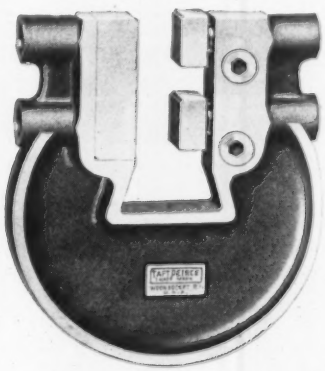
New Flat Plug and Shoulder Snap Gages

(Taft-Pierce Mfg. Co.)

THE flat plug gage incorporates all of the economies of adjustable gaging members. It consists of a well designed and balanced body, shaped to fit the hand conveniently. Its gaging members are the outstanding feature. By an eccentric adjustment they can be expanded, locked, and then reground to original size.

They are made from a special hard steel which gives long wearing-qualities and the interchangeable members can be replaced; hence the life of the gage is unlimited. Expansion of 1/8" is provided to allow a generous number of regrinds.





The adjustable snap gage is designed for checking flat or cylindrical work of plain sections or shoulder work up to a sharp corner as well.

The adjustable member has two square anvils which can be set to any desired limits within its range. A newly designed clamping device locks the anvils securely so that no variation is possible after sealing. The stationary member is rigidly bolted to the frame which is designed specially for convenient handling.

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WATER WORKS JOURNAL. No. 11, November, 1930 issue of this publication contains the following articles: The Toronto Water Works System; Water System Improvements of Cities Total 100 Millions; Winchester, Virginia, Water System; Hard Times, Drought and Unemployment; Why Los Angeles Voted $38,800,000 for Water and How It will be Spent and Coffeyville Water System. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

MICRO-METALLOGRAPH. Catalogue No. 1057, second edition, 44 pages includes a thorough and detailed description of the new micro-metallograph. E. Leitz, Inc., 60 East 10th St., New York.

AUTOMATIC CONTROLLERS. Two small pamphlets, one showing how steel plants are producing better products, and the other how glass plants are producing better ware, because of the L & N Automatic Controllers. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

ELECTRICAL MEASURING INSTRUMENTS. A folder illustrating the increase in the industrial use of electrical measuring instruments. The growth of the L & N plant from 1906 to 1930 is shown. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

GROUNDMETERS. Bulletin No. 120 describes and illustrates some important characteristics of earth electrodes determined by groundmeter measurements. Borden Electric Co., 480 Broad St., Newark, N. J.

VISCO-METER. A booklet entitled,—a practical test for viscosity, which describes the uses and advantages of the visco-meter. Visco-Meter Corporation, 315 Grote Street, Buffalo, N. Y.

ELECTRIC TIME SWITCHES. A circular describing the Jewell Electric Time Switch designed especially for large users of electric time switches, such as, power and light companies, outdoor advertising companies and national chain stores, as well as small users. Time Switch Sales & Service, 1841 Euclid Avenue, Cleveland, Ohio.

AUTOMATIC TIMERS. Circular describing the Walser Automatic Timers which are used in the household, machine shop, factory, and anywhere where interval timing is required. Walser Automatic Timer Co., 1841 Euclid Ave. Cleveland, Ohio.

IGNITION TESTER. Forms 130 and 131 describe the Mallory ignition tester for testing coils, condensers, distributors, synchronizing contact points and accurately testing the ignition governor. Mallory Electric Corporation, Toledo, Ohio.

OSCILLOGRAPH. Reprint No. 439 entitled, Cathode Ray Oscillograph, contains the following two articles, The Position of Cathode Ray Instruments in the Field of Oscillography, by O. Ackermann, and High Voltage Cathode Ray Oscillograph Equipment. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

COMPARATOR. A 10 page booklet describing the slide comparator for colorimetric pH control. W. A. Taylor & Co., Inc., 872 Linden Avenue, Baltimore, Md.

GALVANOMETERS. Circulars 205a-G 97-1130 describes and illustrates lecture room lamp and scale for galvanometers. Leeds & Northup Co., 4901 Stenton Avenue,s Philadelphia, Pa.

FIRE-CONTROL. A leaflet show the Type S-32 fire-control used on oil or gas burning boilers and industrial furnaces, it is electrically operated. General Controls, 241 Tenth St., Oakland, Calif.

METER. Bulletin 985A describes the operation and uses of the moisture meter. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

MANOMETER. A 47 page pocket booklet entitled "The Manometer and Its Uses," by J. B. Meriam. Meriam Co., 1955 West 112th Street, Cleveland, Ohio.

HEATING. Catalog 247, a new publication covering industrial heating equipment. It has 100 pages which includes operating data, charts, tables and installation photographs, also specifications and illustrations of industrial heating equipment. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

FLOW METERS. Type "E" Bulletin No. 7 entitled, "Meriam Made Instruments," describes and illustrates the various instruments made by. The Meriam Co. 1949 West 112th St., Cleveland, Ohio.

VISCOSIMETER. A leaflet describing a quick-reading viscosimeter. Akatos, Inc. 114 Liberty St., New York, N. Y.

THERMOMETRIC LAG, is the title of a 15 page booklet. The data contained herein is taken from a paper on thermometer lag by Harper (Bureau of Standards Bulletin, Vol. 8, 1913). Negretti & Zambra, 38 Holborn Viaduct London, E. C. 1, England.

FLOW CONTROL. Bulletin No. 170 describes and illustrates flow controllers, their uses and operation. Foxboro Co., Foxboro, Mass.

SPERRYSCOPE. Vol. 6 No. 4 of this publication contains various articles on the Sperry Gyroscope, also other articles of interest. Sperry Gyroscope Co., Inc. Manhattan Bridge Plaza Brooklyn, N. Y.

PRECISION INSTRUMENTS. Publication No. 3 describes and illustrates precision instruments and gaging devices. Comtor Company, Waltham, Mass.

EDMOORE. Bulletin No. 20 describes how the Edmoore Power Demand Limitator reduces operating costs by controlling electric power demand. Power Control Corp., Syracuse, N. Y.

PHOTOELECTRIC RELAY. Bulletin No. 124 describes No. 1281 photoelectric relay which is a complete, electrically operated switch controlled by a beam of light. G-M Laboratories, Inc. Grace and Ravenswood Ave., Chicago, Ill.

PROTECTIVE UNIT. A circular describing an automatic excess temperature cutout, which is a protective unit for furnaces. Hevi Duty Electric Co., Milwaukee, Wis.

STARTERS & CONTROLLERS. Bulletin 64 (revised) March, 1929 describes the polyphase motor speed controllers for use with slipring motors in which the maximum voltage between sliprings does not exceed 320. Ward Leonard Electric Co., Mount Vernon, N. Y.

MAGNET VALVES. A circular dated November 1930, describes and illustrates solenoid operated magnet valves, heavy duty relays and contactors, automatic transfer switches, remote control switches solenoids. Automatic Switch Co., 154 Grand St., N. Y.

VIBROSCOPE. A leaflet describing and illustrating the vibroscope model-3, which is a simple portable instrument for studying the behavior of rapidly moving machine parts, while actually in motion. Electrocon Corp. 6 Varick St., New York.

PSYCHROMETERS. A circular describing the Teltru psychrometer, which tells the temperature-humidity accurately, quickly and easily. E. Vernon Hill Co., 121 N. Clark St., Chicago, Ill.

THERMO REGULATOR. File, No. 30f2 describes and illustrates the adjustable mercury thermo regulator. Struthers Dunn, Inc., 139 North Juniper St., Philadelphia, Pa.

MOTORS. A 16 page publication designated as circular 1883 covers the various types of small power motors. It also contains many illustrations showing construction details of the motors, and their applications. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

THE GRAPHIC. No. 11302 of this publication contains the article entitled, "High Speed Graphic Meters on a Modern Power System." Esterline-Angus Co., Indianapolis, Ind.

INDICATING THERMOMETERS. Bulletin No. 20 describes indicating thermometers used to provide an accurate, reliable instrument which is suitable for general industrial application. The Dickson Co., 7420 Woodlawn Ave., Chicago, Ill.

LINE SWITCH. A new leaflet describing the construction, advantages and uses of the type UM-2 electro-magnetic line switch for protecting equipment in electric railway service. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

STRAIN GAGES. A booklet describing strain gages with accessories and other specialties. F. F. Metzger & Son, 2600 N. Sixth St., Philadelphia,

AMPLIFYING EQUIPMENT. A booklet describing amplifying equipment for educational and commercial requirements. Ferranti, Inc. 130 West 42nd St., New York.

VALVES. An 8 page leaflet describing air and vacuum valves. Jas. P. Marsh & Co., 551 Fifth Ave., New York.

FOG HORN. No. 62, December 1930 has the article, "The Synthetic Fibre Trend" by Harold DeWitt Smith. Parks-Cramer Company, Fitchburg, Mass.

MICARTA. A new 16 page, illustrated publication, identified as circular 1686-A entitled "Micarta in the Central Station." Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

RHEOSTATS. Catalog No. 730 describes the tubular rheostat, its usefulness in the laboratory. Hardwick, Hindle, Inc., 215 Emmet St., Newark, N. J.

WATER WORKS JOURNAL. December 1930 issue of this publication contains the following articles: New Filtration, Softening Plant for Bowling Green, Kentucky; Making Good Times; California's Water Convention; Safeguarding Our Water Supply; Merion's New Water Plant is Golf Club Jewel; Little Falls, New York, Water Supply System; and Hydraulically Speaking Water. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

METERS. An illustrated 16 page circular describing watthour and demand meters. This publication is identified as circular 1753-B. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

SEKO. A circular describing Seko apparatus, which takes all the mental calculation out of weighing, counting or estimating. Seeder-Kohlbusch, Inc., 149 New York Ave., Jersey City, N. J.

TURBIDIMETER. Bulletin No. ES describes the operation, application, advantages and price of the Burgess-Parr Tubidimeter. Booklet 112 also gives directions for using this turbidimeter. Burgess Parr Company, 111 West Monroe St., Chicago, Ill.

COLORIMETER. A leaflet giving some of the advantageous features of the Dubosc Colorimeter, Spencer Lens Co., Buffalo, N. Y.

COLORSCOPE. A booklet describing a colorscope for color matching and measurement. Sheldon Electric Corporation, 100 Fifth Ave., New York, N. Y.

SNUBBER FOR PRESSURE GAGES. A leaflet describing a snubber which eliminates vibration, steadies the pointer and takes all wear off inside parts. Pressure Snubber Co. 311 East Fifth St., Charlotte, N. C.

ROUND-O-METER. A leaflet dated Nov. 1930 describes checking of pistons, pins and other round parts for roundness and taper. Automotive Maintenance Machinery Co., 816 West Washington Blvd., Chicago, Ill.

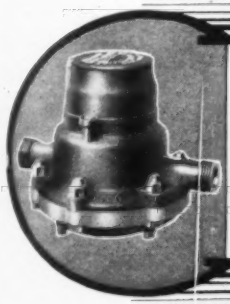
GAS SERVICE JOURNAL. December 1930 issue of this publication contains the following articles; Business is Sometimes Thrilling on the Rio Grande; Following Through with Window-Displays; Saving of Gas in Distribution Mains; Making Good Times; Building Heating Load in Baltimore; Newton, Iowa, Gas Plant; and American Gas Association Offers Samuel Insull Award for Outstanding Progress. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

PRECISION WORK. No. 527 describes a new model of Swiss high speed precision borer, this machine has been designed for handling small work such as laying, drilling and boring holes in dies and instrument parts. Catalog No. 518 illustrates and describes a form of heavy support for measurements and inspection work. R. Y. Ferner Co., Investment Bldg., Washington, D. C.

EXPERIMENTER. Vol. 7, No. 7 of this publication contains an article entitled, "The Home of the Engineering Department," by J. W. Horton. General Radio Co., Cambridge A, Mass.

LABORATORY. Vol. 3 No. 5 of this publication contains among other interesting articles, one entitled, "The Laboratory at the South Pole." Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.

AIR EQUIPMENT. Catalog 4000 entitled, Air Operated Controller Equipment, is devoted to the section on Accessories. Bristol Co., Waterbury, Conn.



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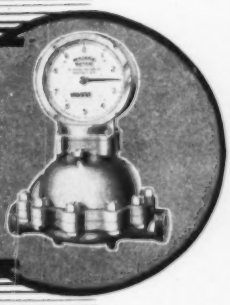

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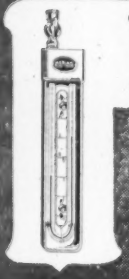

Manometers

THE MERIAM CO.

Madison Avenue at W. 112th Street
Cleveland, Ohio

CURRENT LITERATURE REVIEW

Abstracts on instruments and devices for measurement, inspection and control

The Technology Department, Carnegie Library, Pittsburgh, Pa., will furnish photostats of material abstracted here. Negative prints are 35 cents per page, plus 10 cents for mailing (first class). All orders should be paid in advance. The library is not responsible for loss in mail.

GENERAL

Motor-Vehicle Performance Indicating and Recording Devices. Carl W. Stocks. S. A. E. Journal, Nov. 1930, pages 529-540, 552; Discussion 512-513.

The author's purpose is to enlist greater interest from the manufacturers in the development of more substantial instruments and to point out how these instruments can be used by all classes of motor-vehicle operators. Dividing such instruments into two groups, he sketches a background for the solving of specific problems relating to their use and then describes devices which facilitate operation. Certain instruments intended as a check on operation and designed to furnish definite information through the medium of charts or tapes are commented upon, as well as devices that are primarily designed to assist the driver in the more intelligent operation of his vehicle. Several types of recording devices now available are analyzed, and descriptions are given which illustrate the benefits derived from their usage. The reliability of speedometers in general is doubted unless excessively expensive maintenance methods are applied to them. The author then states what other motor-vehicle carriers are doing to maintain conventional-type speedometers in reasonably good working order, on what mileage basis such instruments are overhauled, and to what extent other types of speed-indicating or mileage-recording devices are used, citing the information obtained from a questionnaire issued by **Bus Transportation** in an attempt to secure data on the subject. He mentions other types of instrument, including tachometers, states their advantages and disadvantages, and advocates the development and use of a device to count engine revolutions accurately, these data to be used in preference to reckon the life of an engine and its allied operating accessories in terms of vehicle mileage. In other words, the author urges the development of an accurate engine-revolution counter and the rating of engine performance by engine revolutions.

Radiation Measurements with Electrical Instruments (Strahlungsmessungen mit Wolfe elektrischer Messinstrumente). Elektrotechnische Zeitschrift, May 1, 1930, pages 643-644.

A new arrangement of Gans & Goldschmidt is described which uses a photo-cell and is therefore suitable to measure objectively without the influence of the human factor. The radiation falling on the photo-cell ionizes the latter and deflects an electric measuring instrument connected with it. The apparatus can serve as photometer, luxmeter, intensity meter, optical pyrometer, for testing of X-ray tubes, and also as colorimeter.—H. A.

Adapting Instrument Control to High-Pressure Operation. Chemical & Metallurgical Engineering, Sept., 1930, pages 582-590.

One of the feature articles in the special High-Pressure High-Temperature Number of this monthly. "Control instrumentation in the high-pressure industries," the article asserts, "has not reached the degree of refinement encountered in the low pressure field." Seven illustrations are published of special instruments, 2 of which are commercial, the others mostly experimental. Other promising experimental instruments are reported in the text. Pressure is the condition emphasized in the article, the others discussed being temperature, flow, level, weight, and gas analysis.—M.F.B.

LENGTH, AREA, VOLUME

Dimensional Changes Caused in Glass by Heating Cycles. A. Q. Tool, D. B. Lloyd & G. F. Merritt. Bureau of Standards Journal of Research, Sept. 1930, pages 627-646.

In obtaining expansivity curves for a medium flint glass, samples of the glass were tested which had previously received one or another of several different heat treatments, and in these tests heating cycles were employed which made it possible to determine the magnitude of the so-called "permanent" changes in length which are caused either by the annealing or the "disannealing" which may result from the heat treatment imposed on the glass by the heating cycle employed. Annealing decreases the length and specific volume, while disannealing increases them. It is shown that these effects are related to certain ice-point shifts observed in thermometers, and to other effects sometimes observed in various types of glassware.

Experiences with the Krupp Test Stand for Measuring Locomotive Wheels. Further Applications of the Krupp Method. (Erfahrungen mit dem Krupp-Messtand zum Nachmessen von Lokomotiv-Radsaetzen und weitere Anwendungen des Krupp-Messverfahrens). A. Leipert. Krupp'sche Monatshefte, Aug. 1930, pages 221-224.

The illustrated article deals with recent experiences of the Krupp method for measuring the exactness of locomotive wheels. The method has been adopted as a standard testing equipment by the German Federal Railway Administration.—G. N.

Cinematographic apparatus for Special Purposes (Filmaufnahmegrate für Sonderzwecke). F. Isermann, Zeitschrift Verein deutscher Ingenieure, Sept. 27, 1930, pages 1363-1366.

A few new apparatus are described and illustrated for slow speed motion pictures, time-reducing pictures, and a tube camera to fix cinematographically i.e. the behavior of ropes during operation or of the inner walls of pipes. One instrument permits 5000 exposures per second whereby 120 m film can be used; and this principle has lately lead to 100,000 exposures in 1 second. The apparatus uses a multiple objective for 28 individual pictures of 15.4 mm² size. A few very interesting special cameras are explained for photographing continually and from different sides.—H. A.

Tools and Measuring Instruments (Werkzeuge und Messgeraete). Munke. Zeitschrift Verein deutscher Ingenieure, Sept. 13, 1930, pages 1253-1257.

Description of a few novelties shown at the Leipzig spring fair. A new shape of milling tools has been developed based on research on milling processes. Some new chucks and shapes of saw teeth are described and other special tools for high-speed cutting of light metals. Further, vises with quick-movement two-part and three-part chucks with pneumatic gripping device. Instruments for absolutely exact testing of tooth-flanks, gages, vernier arrangements for measuring cones and angles are described and illustrated.—H. A.

A Novel Arc-Compass (Ein neuartiger Bogenzirkel). Allgemeine Vermessungs-Nachrichten, Oct. 8, 1930, pages 647-650.

An instrument for the drawing of arcs of very large radius without the aid of French curves. Made by Max Wolz, Bonn.—H. A.

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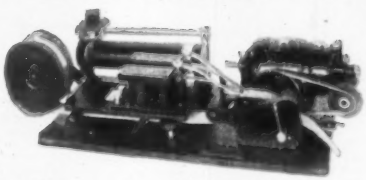

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A Novel Machine for Dividing Circles (Neue Kreisteilmaschine). Messtechnik, Sept. 1930, pages 258-259.
Description of a machine made by Alfred Y. Amsler & Co. in Schaffhausen (Switzerland) which automatically makes circular divisions of angle-measuring instruments up to 600 mm diameter.—H. A.

The Theory of the Planimeter (Die Theorie des Planimeters). K. Trott. Messtechnik, Sept. 1930, pages 240-241.
A short derivation of the equations of operation.—H. A.

An Adjustable Profile Gage (Eine verstellbare Profillehre). Elektrotechnische Zeitschrift, July 10, 1930, pages 1016-1017.
The tool consists of an aluminum frame holding fine sheet strips of brass or non-rusting steel of 0.175 mm. (0.007") thickness. The strips are lightly pressed against the profile so that they arrange themselves exactly as the contours; then they are fixed in this position by set-screws. The tool is made in widths up to 300 mm. and heights up to 190 mm; E. Walter in Berlin-Wilmersdorf is manufacturer.—H. A.

Instruments for Measuring Distances Between Holes (Messgeraete zur Bestimmung von Lochabstanden). Zeitschrift Feinmechanik & Praezision, Oct. 31, 1930, pages 8-9.
This instrument is caliper-form, made by Alig & Bäumgärtel, Aschaffenburg, Germany, permits to measure directly the distance from center to center of 2 holes; the legs are shaped conically, the one rigidly connected to the gage is inserted in 1 hole and the other which can slide on the gage moved until it fits exactly the other hole.—H. A.

High-Frequency Ultra-Micrometer (Das Hochfrequenz-Ultramikrometer). L. Richtera. Elektrotechnische Zeitschrift, May 15, 1930, pages 717-718.
The instrument is to be used for the measurement of smallest changes of length by the changes in the distance of condensor plates. The corresponding change in capacity changes the frequency of the circuit and if another circuit of known frequency is superimposed interference occurs and this is made audible by a sound generator.—H. A.

Adjustable Pin Gage. A. J. Wormwood. Machinery. June 1930, pages 798-799.
Describes and illustrates a pin gage used in place of more expensive plug gages. A pair may be used for "Go" and "Not Go" gages. These gages have been used for measuring holes ranging from $1\frac{1}{2}$" to 2" by $\frac{1}{4}$" steps, and from 2" to 6" by $\frac{1}{2}$" steps.—R. H. P.

Gages for Checking Woodruff Keyways. W. N. Delenk. Machinery. Aug. 1930, page 954.
Illustrates and very briefly describes gages for checking the depth of the keyway, the alignment of 2 keyways in relation to each other, for checking the distance from the shoulder to the center of the keyway, and for checking the distance from the end of the shaft to the center of the key way.—R. H. P.

Gage for Grinding Threading Tools. Arthur Kendall. Machinery, Sept. 1930, page 45.
Gage is circular. Made from a piece of $\frac{1}{8}$" sheet steel. Hole in center is bored to fit a shank of tool rest. Four V-slots for gaging the points of threading tools are cut in its periphery. Slots are cut to different depths to accommodate inside threading tools of different sizes.—R. H. P.

Indirect Volume Finder. Lawrence Hodges. Chemical & Metallurgical Engineering, March 1930, page 180.
Describes a method of determining the volumes of containers, which makes use of Boyle's law in an apparatus in which the container is placed under pressure by means of a water column.—M. S.

Effects Large-Savings by Chromium Plating Gages and Tools. Iron Trade Review, Feb. 27, 1930, page 62.
From **Ford News**, Jan. 15, 1930. Ford Motor Co. has applied hard Cr plate to gages and machine parts resulting in important savings in time and costs. Plate gages formerly giving only 4 hrs. in certain grinding operations, now give 218 hrs., while costs have been reduced more than one-half. A plug gage which, before plating, could be used only 1300 times, can be used more than 18000 times after plating. Gages are carefully tested and checked.—M. S.

One Certain Surface Gage. Fred Rehmann. American Machinist, April 17, 1930, pages 653-654.
Describes in detail and with illustrations the construction of gage consisting of a vertical stand with adjustable and revolving cross rod. Chucks taken from commercial pin vises are soldered to the end of this rod. These chucks hold ordinary needles which may be removed to be sharpened or replaced as necessary.—R. H. P.

A Lip Clearance Gage. A. P. Giviozdowski. American Machinist, May 22, 1930, pages 838-839.
Three things to watch in grinding drills are: 1. Lip clearance, 2. The location of the dead center in relation to the center line of the drill, 3. The angle of the lips. The gage described and illustrated measures these factors. Gaging the drills and grinding properly increases the efficiency of the drills.—R. H. P.

A Large Height Gage. Hans Goldschmidt. American Machinist, June 5, 1930, pages 923-924.
For taking dimensions, checking clearances, etc. from parts high up under the ceiling or in places hardly accessible on account of machinery. Three straight-edges made from hardwood are dovetailed into each other, so as to slide and stay put at any point. The gage may be fixed at any height between 7 and 15 feet. The edges are graduated, and plainly marked so figures are legible at 10 feet. The smaller member has a cross arm graduated in inches.—R. H. P.

SURVEYING

The Cine-Theodolite. Rene Leonhardt. Engineering Progress. July 1930, pages 183-185.
An instrument for recording the line of flight and the velocity of aircraft. Ordinary theodolite is unsuitable due to rapidity of flight and subsequent difficulty in focusing. This is a combination of a cinematograph and a theodolite. For observations 3 are used. The object is focussed through a telescope. Parallel to this is the telescope through which the object is photographed. The objective contains a mirror system of great intensity and focal length. The object is projected on a cinematograph film. Five photos may be taken per second. The camera registers the angle of height and the azimuth angle of the telescope, and also photographs the dial of a clock to identify the exact time of observation. The 3 instruments are checked against each other.—R. H. P.

Sea-Level Determination without Calculation (Einwaegen ohne Rechnung). G. Lips. Allgemeine vermessungs-Nachrichten, Oct. 8, 1930, pages 641-647.
Describes a new method to determine the height above sea-level of a location directly from the transit-readings by means of a special levelling rod.—H. A.

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Flow Tests on Float Measuring Instruments (Stromungstechnische Untersuchungen an Schwimmermessern). G. Ruppel & K. J. Umpfenbach. Zeitschrift Verein deutscher Ingenieure, Aug. 23, 1930, page 1184.

An investigation into the influence of viscosity of the liquid on the position of the float. Curves of constants have been taken in numerous tests and calibrations with water, oils and steam.—H. A.

Comparative Measurements of Water in the Power Station of Lake Walchen (Vergleichswassermessungen am Walchenseewerk). O. Kirschner. Zeitschrift Verein deutscher Ingenieure April 26, 1930, pages 521-528.

The lack of a universally recognized method for determining the quantity of water flowing in rivers, channels, turbine pipes, etc. caused the Canadian & General Finance Co. of London in cooperation with the Bayernwerk and other firms to compare the 4 most used methods: the salt-velocity method, the propeller (vane) method, the Pitot-measurement, and the Gibson method. The arrangements and instruments are described in detail; the conclusion is that, for measuring water-flow and turbine efficiencies, the differences in the four named methods are still too great for the guaranties which are usually given nowadays by manufacturers. A definite method should therefore be stipulated. 8 references.—H. A.

Oil Meter Notes. H. L. Kaufman. Industrial Record, Dec. 1930, page 30.

A brief discussion of volumetric meters for gasoline, kerosene, fuel oil, etc.—M. F. B.

GASES, AIR AND STEAM

Measurement of Flow of Coke Oven Gas. J. M. Spitzglass. Fuels and Furnaces, July 1930, pages 943-945.

From paper read before the Association of Iron & Steel Electrical Engineers at Youngstown, Ohio. Discusses density factor of a gas at varying conditions of flow, and describes a method for simplifying the process of flow measurement in connection with coke-oven gas.—M. S.

Determining Air Flow in Agitation Problems. H. L. Kaufman. Chemical & Metallurgical Engineering, March 1930, pages 178-180.

Presents charts and methods of calculating relations of flow, velocity and pipe diameter; relations of flow, pipe diameter, and suction loss; and the flow through orifices of various diameters up to 4 in. at pressures up to 10 lb.—M. S.

Meter Prover for Very Slow Rates of Flow. A. Lawrence Hodges. Chemical & Metallurgical Engineering, May 1930, page 319.

Apparatus for calibrating gas meters consists of a calibrated brass cylinder attached at the top by means of glass tubing and metal pipe to the meter under test. A second glass tube attached to the bottom of the cylinder leads to the bottom of a cistern of smaller diameter, in which is a float carrying the submerged end of a siphon. A stop-cock or pinch-cock at the outer end of the siphon is used to adjust the rate of flow. Explains method of operation.—M. S.

ELECTRICITY

New Method for Testing Varnished Cloth Tape. Warren Master. Electrical World, Sept. 20 1930, page 534.

The research bureau laboratory of the Brooklyn Edison Co. has developed a new method of preparing varnished cloth tape for dielectric strength tests. The problem of sealing the edges of narrow types against flashover has been solved without the use of materials detrimental to the varnish film. Two pieces of rubber tape are placed side by side about $\frac{1}{16}$" apart, the cloth tape placed centrally along the space between them, using slight pressure on the edges of the cloth tape to insure adhesion to the rubber. Another length of rubber is applied along each edge and directly on top of the lower rubber tapes. After alignment of the tapes, they are firmly pressed together and seal the edges of the sample. Putting the separator sides of the rubber together insures maximum fusion. The apparatus employed and the modified A. S. T. M. type tester in locked position with electrode in place are illustrated also the method of testing the varnished cloth tape. —W. H. B.

Apparatus for the Measurement of High Constant or Rippled Voltages. L. S. Taylor. Bureau of Standards Journal of Research, Sept. 1930, pages 609-618.

An improved form of high resistance to be used as a high-voltage voltmeter multiplier for use up to 150 kv. is described. The total resistance is 100 megohms, designed to be coronaless by placing one hundred 1-megohm resistors in 20 corona cases containing 5 resistors each, the corona cases being mounted in series on top of each other. The complete unit is readily portable. Methods of calibrating the resistance under full-load conditions are described. Errors are discussed and necessary corrections, to give a maximum error in high-voltage measurement of 0.01 per cent, are given. A new type of high-voltage string electrometer for use in connection with the resistance is also described.

Note on the Electrical Resistance of Contacts between Nuts and Bolts. F. Wenner, G. W. Nusbaum & B. C. Cruickshanks. Bureau of Standards Journal of Research, Sept. 1930, pages 757-766.

Measurements were made of the electrical resistance between nuts and bolts, using two radically different types of threads, the American National and the Dardelet, and different materials. The test specimens were three-fourths inch bolts of copper, brass, bronze, and steel with nuts of the same materials. The resistances between nuts and bolts were measured with stresses in the bolts, applied by turning the nuts, in the range from near zero to well toward the elastic limit of the materials. It was found that the contact resistance is usually less than a 1-inch length of bolt and that under similar conditions the resistance of the Dardelet thread is, in general, not more than one-fourth that of the American National thread. The maximum resistance found were for steel bolts having the American National thread. For these with a stress of 2,000 lbs./in.^{2} in the bolts the resistance is about 10 microhms, which is the resistance of about an inch length of the bodies of the bolts. The minimum resistances found were for copper bolts having Dardelet threads. For these, with a stress of 6,000 or more lbs./in.^{2} in the bolts, the resistance is of the order of 0.02 microhm which is the resistance of about one sixty-fourth inch length of the bolts.

A Double-Range Electrostatic Voltmeter for 200 Kilovolts. Harry Clark. Review of Scientific Instruments, November 1930, pages 615-620.

The electrostatic voltmeter described in this paper consists, from an electrical standpoint, of two meters which may be used in series or in parallel. Mechanically, however, it is essentially a single meter, since it contains only one moving part. With the parallel connection voltages between 15 and 100 kv may be measured to within .1 of 1%. With the series connection and voltages between 100 and 200 kv (one half on either side of ground the halves fairly well balanced) the error need not exceed 0.1 of 1%.

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The Properties of Sputtered Metal Resistors. L. C. Van Atta. Review of Scientific Instruments, November 1930, pages 687-690.

Satisfactory high resistances have been made by sputtering platinum on soft glass rods and embedding the rods in paraffin in glass tubes for protection. These resistances are useful for measuring small currents in conjunction with an electrometer, by the resistance shunt method. When properly prepared, sputtered resistors are found to change but slowly with age (tests lasted over 12 months), thus overcoming the principal defect of sputtered metal resistors. They fulfill the following requirements excellently: no trace of polarization, a negligible temperature coefficient, and Ohm's Law is obeyed.

Accurate Method of Measuring Transmitted Wave Frequencies at 5,000 and 20,000 Kilocycles per Second. E. L. Hall. Bureau of Standards Journal of Research, Sept. 1930, pages 617-652.

The measurement of the frequency of a radio transmitting station offers a convenient means for intercomparison of frequency standards. While there have been several articles published dealing with station frequency measurements, these have, for the most part, considered frequencies in the broadcast band or lower. This paper describes a method of measuring station frequencies applicable to any frequency, but dealing primarily with frequencies of approximately 5,000 and 20,000 kc. A high order of precision is obtained by the use of harmonics and audio-frequency beat notes. Most of the units of the equipment employed have been previously described in connection with other applications.

Thermo-Wattmetric Measurements of Losses in Large Capacitors (Thermowattmetrische Verlustmessungen an grossen Kapazitaeten). G. Zickner & G. Pfestorf. Report of the Physikalisch-Technische Reichsanstalt. Elektrotechnische Zeitschrift, Dec. 4, 1930, pages 1681-1684.

The usual method of measuring very small electrical energies fail at very low power factor where comparatively large currents occur. In this case, the thermo-wattmeter as recently developed by P. J. Kipp & Sons has proved to be of great advantage. The instrument consists of 2 heating wires which are heated by 2 branches of the current to be measured; they are surrounded by thermo-couples which are connected in opposition through a sensitive (mirror) galvanometer. There is perfect balance and therefore no deflection of the galvanometer as long as no current flows. But as soon as a current is established the balance between the 2 heating wires is disturbed and the difference in the e. m. f.'s in the thermo-couples causes a deflection of the galvanometer. The theory of the instrument is derived and it is shown that the deflection is in proportion to this difference, the constant of the instrument is almost a straight line so that for most practical purposes the deviation from the straight line can be neglected. However, the exact determination of the constant is described and a few examples show the application of the instrument and the evaluation of its readings.—H. A.

Electrical Voltage Regulation by Means of Carbon-Pressure Resistors (Die elektrische Spannungsregelung mittels Kohledruck-Widerstaenden). Hugo Grob. Elektrotechnische Zeitschrift, Dec. 11, 1930, pages 1717-1720.

After a discussion of the property of carbon to change its contact resistance from one carbon plate to another greatly by varying pressure between them the fundamentals and practical possibilities for voltage regulation by means of stacked carbon resistors which can be compressed more or less are described and several types of such regulators are illustrated.—H. A.

New Indicating and Recording Methods in Remote Measuring Technique (Neue Anzeige- und Registriermethoden in der Fernmesstechnik). Walter Stern. Elektrotechnische Zeitschrift, Jan. 16, 1930, pages 77-80.

It is shown in which way remote measuring installations can be combined with remote control installations. In connection herewith, a new method is described to record individual and total sum of energies for feeder lines; the diagram of the total is automatically recorded.—H. A.

Voltage Measurements with Spark-Gaps between Spheres in Air (Spannungsmessungen mit der Kugelfunkenstrecke in Luft). W. Estorff, Max Toepler, Siegfried Franck. Elektrotechnische Zeitschrift, May 29, 1930, pages 777-782.

At the instigation of the International Electric Commission experiments have been carried out to define more accurately the formula of Peek used in the calibration of spark-gaps. Certain discrepancies were eliminated and a new calibration table was made up for spheres of equal diameter in air varying from a diameter of 2 to 50 cm. These tables are reproduced and the measurements, curves and mathematical development explained in detail.—H. A.

Arrangement for Testing and Measuring High-Tension Installations (Einrichtung zum Pruefen und Messen von Hochspannungsanlagen). K. Taeuber. Elektrotechnische Zeitschrift, Aug. 7, 1930, pages 1125-1128.

A test installation is described which is used on the electrified sections of the German State Railroads, but can be used in any other high-tension circuit, for measuring short-circuit, ground, rupture, inductive and capacitive loads, leak due to faulty insulation, and locating of faults, under high-tension by means of a transformer.—H. A.

Advancement in Cathode-Ray Oscillographs by Continuous Operation with Metallic Discharge Tubes and by Exterior Photography of Phenomena of very short Duration (Fortschritte am Kathodenstrahl-Oszillographen durch Dauerbetrieb mit Metallentladungsroehren und durch Aussenphotographie sehr kurzzeitiger Vorgaenge). M. Knoll, H. Knoblauch, & B. V. Borries. Elektrotechnische Zeitschrift, July 3, 1930, pages 966-970.

Report of the High-Tension Laboratory of the Technische Hochschule Berlin. The discharge tubes of glass so far used almost exclusively in the cathode-ray oscillograph with cold cathode do not give satisfaction especially if continuous operation is required as for recording in electric circuits or power stations. A metallic discharge tube is described for continuous operation at 40 to 90 KV and 1 to 5 mA. The fully utilized intensity of the cathode ray renders even at high writing velocities a magnetic pre-concentration unnecessary which results in a shorter length for the apparatus. With this metallic tube writing velocities of almost 5000 km./sec. have been attained for recording of oscillograms outside the tube through an electron window; these velocities can be increased for records in the interior. The dissolving of a billionth of a second (10^{-9}) has been accomplished by this arrangement. Full description of the apparatus and 37 references are given.—H. A.

Sources of Error by Unsuitable Screening When Measuring Losses (Fehlerquellen durch ungeeignete Schirmung bei Verlustziffermessungen). K. Schaudinn. Elektrotechnische Zeitschrift, June 19, 1930, page 910.

Attention is called to errors which may influence seriously the measurement of dielectric losses of bushings. In order to eliminate this influence the bushings must be arranged in a certain way without screen when their losses are measured.—H. A.

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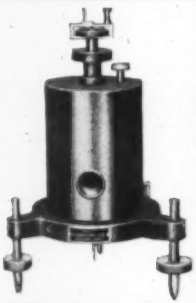

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New Electrolytic Bridge with Alternating Current Indicating Galvanometer as Zero Instrument (Neue elektrolytische Messbruecke mit Wechselstrom-Zeigergalvanometer als Nullinstrument). Elektrotechnische Zeitschrift, June 5, 1930, page 816.

Description of a Wheatstone bridge for the determination of conductivity of electrolytes in which the usual telephone is replaced by new sensitive alternating galvanometer which has a sensitivity of 10^{-7} ampere. A further advantage is that the instrument does not require a special source of alternating current but can be connected to any lighting circuit. The instrument is made by Gans & Goldschmidt, Berlin, Germany.—H. A.

The Spherical Field at Different Phases of the Voltage (Das Kegelfeld bei beliebigen Phasenverschiebungen der Spannungen). S. Franck. Elektrotechnische Zeitschrift, Nov. 20, 1930, page 1627.

Theoretical investigation of the distribution of electric field around spheres of the same diameter at different voltages and communication of test results.—H. A.

Method for Recording Capacity Changes and its Application for the Continuous Observation of Physical Phenomena (Methode zur Registrierung von Kapazitaetsaenderungen und ihre Anwendung zur laufenden Beobachtung physikalischer Vorgaenge). A. Schulze & G. Zickner. Elektrotechnische Zeitschrift, Nov. 20, 1930, pages 1626-1627.

By means of a capacity bridge the capacity to be determined is converted into a voltage or a current to make the use of an instrument possible. The theory of this method is derived and a few tests reproduced.—H. A.

Diagram for Determination of Errors Due to Instrument Transformers for Measurements of Energy in Three-Phase Three-Wire Installations (Diagram zur Ermittlung des durch Messwandler entstehenden Fehlers bei Leistungsmessungen in Drehstrom-Dreileiteranlagen). H. Neutzeberger. Elektrotechnische Zeitschrift, Nov. 20, 1930, page 1625; Archiv Elektrotechnik, Nov. 1, 1930, page 29.

Derivation of the diagram from which the errors can be taken graphically.—H. A.

An Electrical, Direct-Reading Vacuum-Meter Based on the Anormal Cathode Gradient (Ein elektrisches direktzeigendes Vakuummeter auf dem Prinzip des anomalen Kathodenfalles). M. Wellauer. Elektrotechnische Zeitschrift, Nov. 13, 1930, page 1592; Archiv Elektrotechnik, Vol. 24 No. 1 (1930), page 4.

The current in a vacuum tube depends on the gas pressure when the cathode gradient has become abnormal. This principle is used in the instrument which consists of a transformer of about 50 watts giving about 7000 Volts, the discharge tube and a stabilization resistance with an ammeter as vacuum indicator. The arrangement is not sensitive against exterior influences.—H. A.

The Measurement of High-Voltages of Alternating Current by the Magnet Field of the Displacement Current. (Die Messung hoher Wechselstromspannungen aus dem magnetischen Feld des Verschiebungsstromes). H. Laub. Elektrotechnische Zeitschrift, Nov. 13, 1930, page 1593; Archiv Elektrotechnik Vol. 23, No. 6 (1930), page 643.

The author finds that it is possible to determine high voltages by the magnetic field produced by alternating current of technically used frequencies; the voltage induced by the latter is proportional to the second differential quotient of the high voltage and therefore a measure for this voltage. Two different arrangements, one with glass as dielectricum, one with air, are described.—H. A.

A Direct-Reading Alternating-Current Compensator (Ein Wechselstromkompensator mit direktem Zeigerausschlag). Martin Wald. Elektrotechnische Zeitschrift, Nov. 13, 1930, pages 1583-1584.

The apparatus consists of 2 dynamometers with automatic adjustment so that the alternating current voltage to be measured is compensated. This makes possible a convenient and quick measurement, an advantage particularly valuable when long series of measurements have to be made. The theory and application of the method is described in detail.—H. A.

Voltage-Path Connections for Iron-Less Electro-Dynamic Precision-Wattmeters (Ueber Spannungspfad-Schaltungen fur eisenlose elektrodynamische Praezisions-Leitstungsmesser). W. Geyger. Elektrotechnische Zeitschrift, Nov. 6, 1930, page 1564.

An investigation into the accuracy and errors of instruments for connections with and without use of parallel resistances for extension of the measuring range.—H. A.

Measurement of Small Alternating Current Energies at Large Phase-Differences (Messung kleiner Wechselstromleistungen bei grossen Phasenverschiebungen). W. Spielhagen. Elektrotechnische Zeitschrift., Nov. 6, 1930, pages 1563-1564; Archiv Elektrotechnik Vol. 24 No. 6 (1930), page 609.

Very small energies as they occur for instance in corona losses can according to a method developed by the author be measured by a zero-method with the use of a mirror-galvanometer. In the movable coil of the galvanometer a current is produced by properly adjusting one inductive and one ohmic resistance in such manner that it lags behind the current in the stationary coil just 90°, the galvanometer then has no deflection. The phase angle can be calculated from the resistances.—H. A.

Measurement of Variable Currents by Means of Vapor Lamps (Messung veraenderlicher Stromwerte mittels Glimmlampen). Armin Koerblein. Elektrotechnische Zeitschrift., Oct. 23, 1930, pages 1486-1489.

To determine the peak values of currents of short duration, f.i. short-circuits, over-current relays starting current of motors, the ignition voltage of vapor lamp or evacuated tubes is made use of. The tubes are connected in potentiometer connection to a known resistance through which flows the current to be measured. If the voltages available are too small the lamps are ignited by intercalation of a transformer, or, for direct-current, of an additional voltage. A few examples of practical applications are described.—H. A.

A New Ammeter for Large Currents (Ein neues Hochstrom-Amperemeter). J. M. Pestarini. Elektrotechnische Zeitschrift, Sept. 25, 1930, page 1370.

The measurement of very large direct currents of the order of 20,000 to 50,000 amp. is fairly difficult as the conductors have to be opened for shunts. The present arrangement uses a concentric iron ring around the cable carrying the large current; this ring has a cylindrical opening in which a little armature, similar to the moving coil of a d'Arsonval-instrument is mounted and driven by a motor. The voltage produced in this way is measured and then the flux in the iron ring is counteracted by the excitation of a secondary winding on the iron ring in a direction opposite to that of the principal current until the little armature does not show any deflection. Then the current in the cable is equal to the product of the current in the secondary winding with the number of turns of the latter. In order to compensate for the large hysteresis of this device, a tertiary winding is provided through which alternating current is sent, and the whole is protected against exterior magnetic fields by an iron case. The instrument is built by Jules Carpentier, Paris.—H.A.

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Measurement of the Reactive Power Component (Messung der elektrischen Scheinleistung). E. Knoesel. Elektrotechnische Zeitschrift, Oct. 30, 1930, page 1530.

In an inductively loaded alternating circuit, the positions of the index of an ammeter and a voltmeter are transmitted to logarithmically subdivided resistances, and these are connected in series with a constant source and an instrument which gives the sum of the 2 logarithmic indications and therefore the product of the former, that is the energy.—H. A.

Static Reduction of Frequency in a Cathode Qscillograph (Statische Reduktion einer Frequenz bei Kathodenoszillographen). F. Vecchiacchi. Elektrotechnische Zeitschrift, Oct. 30, 1930, pages 1529-1530.

Describes an arrangment for photographic fixation of an oscillation of too short duration for direct action.—H. A.

Complex Alternating-Current Compensator for High Voltages (Ein komplexer Wechselstromkompensator fuer hoehere Spannungen). W. Geyger. Elektrotechnische Zeitschrift, Oct. 23, 1930, page 1496; Archiv Elektrotechnik, Vol. 23, No. 4 (1930), page 447.

This instrument permits the direct compensation of about 100V instead of usual 1-10V and is based on a measuring principle using 2 voltages in 90° phase difference which can individually be regulated with regard both to magnitude and direction. A vibration galvanometer is used as zero-instrument.—H. A.

The Cross-Coil Ohmmeter in Remote Measurements (Das Kreuzspul-Ohmmeter in der Fernmesstechnik). J. Moeller. Zeitschrift Feinmechanik und Praezision, Sept. 30, 1930, pages 5-9.

The instrument has a strong permanent magnet with cylindrically shaped poles between which an elliptical iron core is arranged. In the air space between magnet and core a double-coil consisting of 2 coils at right-angles to each other on the same shaft, the 2 coils have different resistance and are connected in parallel. As the number of turns is the same in both coils it is shown that the system assumes a position in the field where the ratio of magnetic flux through the coils is the same as the ratio of their resistances. The methods of connection for a few applications are given.—H. A.

Experiments with the Oscillograph of Schuerholz-Sprenger (Versuche mit dem Schuerholz-Sprengerschen Oszillographen). W. Hohmann. Zeitschrift Feinmechanik und Praezision, Sept. 30, 1930 pages 1-5.

This instrument has been developed for the special use in schools, colleges etc to demonstrate periodical phenomena to a greater audience. It consists mainly of a very sensitive electromagnetic oscillating system with a mirror almost free of friction and a rotating mirror. The reproduced photographs show very clear pictures of alternating and superimposed currents of 775 cycles, acoustic waves and transient phenomena.—H. A.

Method for Measuring the Resistance of Direct-Current Machines (Verfahren zur Widerstandsmessung bei Gleichstrommaschinen). Heinr. Sequenz. Elektrotechnische Zeitschrift, May 22, 1930, pages 736-738.

Description of a modification of a method of Muellendorf which necessitates at least 2 brushes on each brush stud in such manner that the method can be applied also for machines with only one brush per stud; except however macnines having altogether only 2 studs.—H. A.

Theoretical Basis of Measurements of the Reactive Component in Three-Phase Three-Wire Circuits with Ferraris-Meters (Theoretische Grundlagen der Blindverbrauchsmessung im Dreileiter-Drenstrommetz mit Ferrariszaehlern). G. Hauffe. Archiv fur Elektrotechnik, Vol. 22 No. 6 (1930) page 542; Elektrotechnische Zeitschrift, April 24, 1930, pages 612-613.

A discussion of the different means to create a phase difference of 90° between voltage and current in these apparatus. The application of the developed formulas is illustrated by an example.—H.A.

A Connection for Instantaneous Response of Cathode-Ray Oscillographs (Eine Sprungschaltung fuer Sperr-und Zeitkreise fuer Kathodenstrahl-Oszillographen). Willi Krug. Elektrotechnische Zeitschrift, April 24, 1930, pages 605-609.

The arrangement and action of a time relay is discussed which operates discontinually and brings the cathode ray to respond within 10^{-8} seconds if a deflecting cause occurs. With this new connection, it has been possible to record surge waves with such high abscissa-velocity that all details become clearly visible. Oscillograms of waves of 6000 volts of a breaker are reproduced showing these details. The apparatus is fully described; 15 refetences.—H. A.

Measuring Power in the Foundry. "Kilowatt." Foundry Trade Journal, May 22, 1930, page 476.

Describes a number of measuring instruments in general use in the foundry; such as voltmeter, ammeter, wattmeter, watt-hour meter, ampere-hour meter, ohmmeter, power factor meter and several others.—V. S. P.

Cathode-Ray Oscillograph with Lenard Window. M. Knoll. Review of Scientific Instruments, Sept. 1930, pages 507-511.

Descriptions of experiments with electron windows of very thin glass (5 to 10 mu), of aluminum foil, etc., which were carried on in the Hochspannungslaboratorium of the Technische Hochschule, Berlin. Methods of supporting windows. Determination of effects of scattering of electrons in the foil, and of X-ray's, on distinctness of oscillograms. Conclusion that combination of flat electron window and flat photographic layer is preferable for certain purposes mentioned where free-air photography is itself preferable to high-vacuum recording. Subsequent work with cellon-foil window 16 mu thick supported by fine phosphor-bronze mesh backed by steel ribbon grid, only the latter showing as a faint shadow on oscillograms and thus serving as a coordinate system. Maximum recording speed increased to 5000 km per sec. allowing dissolving phenomena of order of a billionth of a second.—M. F. B.

A Precision Audio Frequency Bridge. Paul H. Dike. Review of Scientific Instruments, Dec. 1930, pages 744-748.

Developed in the Leeds and Northrup Laboratory, this new bridge is characterized by a high degree of sensitivity and accuracy and has proved extremely useful for the testing of resistors, inductances and condensers. Among other features, a remarkably thorough system of shielding and grounding (fully described) ensures that the detector terminals are at ground potential when the bridge is balanced, and makes the bridge balance independent of capacitances to ground of the input leads or of the source of power. The bridge is designed to operate on a range of frequencies from 500 to 3000 cycles sec. Methods are described for five typical applications: 1. Resistance. 2. Inductance of Resistors. 3. Low Inductances. 4. Comparison of Inductances. 5. Comparison of Condensers. 6. Temperature Measurements.—M. F. B.

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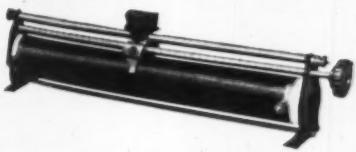

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TEMPERATURE AND MOISTURE

Some Improvements in Thermoregulators. Henry J. Wing. Industrial & Engineering Chemistry, Analytical Edition, April. 15, 1930, pages 196-197.

A toluene regulator with mercury reservoir and hydrogen contact chamber is described in detail. 4 references are given.—M. E. H.

Preparation of Air of Known Humidity and Its Application to the Calibration of an Absolute-Humidity Recorder. A. C. Walker & E. J. Ernst, Jr. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, pages 134-138.

An apparatus is described whereby constant flowing mixtures of air and water vapor may be prepared, in which the moisture content varies not more than 0.001 per cent by volume, over long periods. This apparatus has been utilized to calibrate a sensitive humidity recorder capable of continuously recording atmospheric humidities up to 2.9% water vapor in air with a sensitivity of 0.0016%. 5 references.—M. E. H.

A High-Sensitivity Absolute-Humidity Recorder. Crandall Z. Rosecrans. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, pages 130-134.

An apparatus has been developed for measuring and recording the amount of water vapor in the air, which is suitable for recording humidities from zero up to saturation within a temperature range from -100 to about 200° C. The apparatus is based on the measurement of the thermal conductivity of water vapor and air mixtures, and is continuous reading. 12 references.—M. E. H.

Calibration of Standard Lamps for Relative and Absolute Measurements. L. S. Ornstein, D. Vermeulen & E. F. M. van der Held. Journal Optical Society, Oct. 1930, pages 573-584.

For accurate work in the measurement of intensities there are required standard constant light sources. The authors distinguish between relative standard lamps in which the spectral energy distribution is known, and absolute standard lamps in which the absolute intensity at one particular wave length is known. The former are especially necessary for the photographic method of comparing spectral line intensities and for the measurement of the sensitivity curve of a combination monochromator-and-photocell or of a monochromator-and-thermopile. Two different methods of measuring the spectral energy distribution in the visible region in a tungsten lamp are described. (1) Photographic method—Constant-voltage lamp, lens, monochromator and second lens, producing image in one color determined by middle slit of monochromator. Energy of image is measured for various wave lengths by thermopile and galvanometer. Deflection divided by corresponding wave length region gives relative intensity distribution as function of wave length. By taking out middle slit, a white image of known spectral energy distribution is obtained. By means of this image an arbitrary continuous light source is calibrated photographically (manner of eliminating selective properties of spectrograph described; diffuse reflector eliminates chromatic aberration in lenses). Thus the photographic method is independent of any temperature measurement. (2) Pyrometric method—The "optical pyrometer principle." Authors have measured tungsten bands and spiral filaments, and discuss differences in brightness of inner and outer surfaces of the latter, giving calculations. Other subjects reported upon and discussed, and instruments described, are: Temperature Measurements from Measurements of the Energy in Two Colors; Temperature Measurements with the Monochromator; Temperature Measurements with a Photo-Cell, Red and Blue Filter; Absolute Calibration of a Standard Lamp; Determination of the Coefficient of Transmission; Total Calculated Relative Energy; The Thermopile, and the Pyrometer.—M. F. B.

Thermostatic Melting Pot Control. Brass World, Sept. 1930, page 250.

The thermostat designed by the General Electric Co., Schenectady, N. Y. for controlling the temperature of soft metal melting pots for use with lead, tin, babbitt, solder, etc.. It consists of an enclosed switch and a nickel-chrome iron tube extending from its base and surrounding a steel piston and quartz rod. The thermostat range is 450-950° F., controllable within plus or minus 14 of its settings. It is inexpensive with a high degree of accuracy.—W. H. B.

Thermometer Records Temperatures in Ducts. Electrical World, Oct. 4, 1930, page 670.

Duct-recording thermometers comprising a flexible steel fish wire terminated by a tiny hardened steel case inclosing a 0-100° C. thermometer have been marketed by the Cable Accessories Corp., Pittsburgh, Pa. The thermometer is thrust between the cable and the duct wall to a depth of 8-10 ft. and an interval of 15 minutes is required for the thermometer to reach its full reading.—W. H. B.

Radiation Thermopile Design. F. A. Firestone. Review of Scientific Instruments, November 1930, pages 630-649.

Previous formulas for the design of radiation thermopiles to be used with a Thomson galvanometer are summarized and new formulas for the design of thermopiles for use with D'Arsonval galvanometers are developed. A design of thermopile is described in which the cold junctions almost entirely surround the hot junctions thus reducing drifts. In this design, each element is constructed as a separate unit and when all are completed they are simply stacked up and fastened together with one screw, thereby minimizing the danger of breakage. The whole thermopile fits into a cubical evacuated case only 10 mm on an edge and, being so small, it can be used directly in front of an elliptical mirror which forms a small hot image, in some cases increasing the deflection due to a given radiation by a factor of 3. By a slight modification of the spectrometer, a thermopile having adjustable compensation can be utilized which, theoretically, will give almost no drifts due to changes in temperature of the optical parts of the spectrometer or of the surroundings. A convenient technique of construction is described.

Measurement of Surface Temperatures. Wm. F. Roeser and E. F. Mueller. Bureau of Standards Journal of Research, October 1930, pages 793-802.

After a brief discussion of some of the methods which have been used for measuring surface temperatures, the paper describes a surface thermometer of the thermocouple type which was successfully used for measuring the temperatures of steel rails during the periods of heating before and after welding. A compensated type of thermocouple, for more precise measurements at temperatures below 400° F., is also described, and results obtained in measuring the temperature of a drying roll are given.

Millivolt-Temperature Relation of the Standard Air Corps Iron-Constantin Thermocouple. G. C. Schleter. Air Corps Circular, Vol. VII, No. 654. Published by the Chief of the Air Corps, City of Washington, 1930.

The results of this calibration for the iron-constantin thermocouple show an accuracy of a fraction of a degree for the lower part of the range and 1° for the upper part of the range.

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Thermoelectric Lag of Aircraft Thermometers, Thermographs, and Barographs. H. B. Hedrick. Bureau of Standards Journal of Research, Sept. 1930, pages 695-709.

A constant which will be called the time lag has been determined experimentally for thermographs, barographs, and of the temperature element of a Fergusson meteorograph. When the instruments are exposed in the same medium and to the same ventillation this constant can be used to evaluate their thermometric lag. For the purpose of comparison this constant was also measured for a number of laboratory thermometers. The tests on the thermometers and thermographs were made in an air stream of 17 m. p. h. and those on the barographs in still air and in an air stream of 10 m. p. h. Results for the thermometers show that the liquid-filled type has the greatest time lag and therefore under similar conditions of exposure the greater thermometric lag, followed in order by the bimetallic strip type and the electric resistance thermometers. All of the barographs, even the metal-cased types, have a far greater time lag than the thermometers, but the lag is reduced considerably by moderate ventilation. The lag of the thermometers ranged from 3 to 72 seconds whereas that of the barographs in still air ranged from 22 to 64 minutes. The lag of the temperature element of the meteorograph was found to be 3 minutes in still air and 11 seconds in an air stream of 17 miles per hour.

Tests with Fever-Thermometers (Ueber einize Versuche mit Fieberthermometern). H. Eberz. Glass und Apparat, Oct. 5, 1930, pages 179-180.

The author calls attention to certain irregularities in the indications of the maximum device and tries to find some explanation for it. A comparison of the requirements for these thermometers in different countries is added as well as five references.—H. A.

Amplification of Small Thermo-Potentials (Die Verstaerkung kleiner Thermospannungen). Josef Kroenert & Hildegard Miething. Wissenschaftliche Veroeffentlichungen aus dem Siemens-Konzern, Vol. 9, No. 2 (1930) pages 112-118.

All electric temperature measuring methods only produce extremely small currents which are sufficient to operate indicating instruments but too weak to permit the connection of recording apparatus. This, however, is very often necessary and in a case where the temperature of steel ingots before and after each pass had to be measured and in a very short time at that an amplification of these currents was resorted to in the same manner as used in radio transmission. The paper discusses the conditions required for an amplification and describes the apparatus which records the thermo-voltages produced in an Ardometer.—H. A.

Temperature Measurement of Commutators during Operation (Beitrag zur Temperaturmessung von Kommutatoren im Betrieb). A. Schliephake. Elektrotechnische Zeitschrift, Aug. 7, 1930, pages 1128-1130.

Two methods are described, one using a thermometer attached to the rotating body and observed stroboscopically, the other using a stationary thermometer which is mounted as close as possible to the rotating body in such manner that very little heat is lost during transmission from the rotating to the stationary body.—H. A.

Electrical Heat-Measuring Instruments (Elektrische Waermemessgeraete). Przygode. Elektrotechnische Zeitschrift, July 17, 1930, pages 1047-1049.

After a short discussion of the advantages of correct determination of the temperature in all processes in the production of steel and iron pyrometers, thermo-couples and resistance thermometers of various makes which were exhibited at the Foundry Exposition in Duesseldorf are described and illustrated.—H. A.

Automatic Reversing Open Hearth Furnaces. Bradley. Fuels & Furnaces, July 1930, pages 979-980, 986.

Paper read before the Association of Iron and Steel Electrical Engineers, June 16-20, 1930. Describes the control system developed by the Leeds & Northrup Co., which is based on the temperature difference method of control.—M. S.

New Humidity Chart Simplifies Combustion Gas Problems. Sirozi Hatta. Chemical & Metallurgical Engineering, March 1930, pages 164-166.

Presents a revised formed of high-temperature psychrometric chart for air and combustion gases based on lb.—mols of water vapor and dry gases, and a humidity chart for air at temperatures of 30°-240° F.—M. S.

Testing and Rating of Fuel Fired Industrial Furnaces. Pt. XVI. Measurement of Temperature in Furnace Testing. W. C. Buell, Jr. Fuels and Furnaces, June 1930, pages 809-810.

Gives some general comments on measuring and recording temperature, but does not go into detail regarding instruments. M. S.

CALCULATION

Recent Types of the Mercedes-Euclid Calculating Machines (Neuere Modelle der Mercedes-Euklid-Rechenmaschine). J. Arns. Allgemeine Vermessungsnachrichten, Oct. 29, 1930, pages 699-702.

Short description and illustration of manually and automatically operated machines.—H. A.

Graphical Integration of Normal Differential Equations of the Second Degree (Zeichnerische Integration gewoehnlicher Differentialgleichungen zweiter Ordnung). V. Blaess. Elektrotechnische Zeitschrift, Jan. 30, 1930; page 183. Zeitschrift fuer Technische Physik, Vol. 9 (1930) page 7.

A graphical method for the integration by means of Taylor's series which permits a fairly good accuracy.—H. A.

A Slide Rule for Calculation with Complex Quantities (Ein Rechenschieber fuer das Rechnen mit komplexen Groessen). W. H. Grinsted. Elektrotechnische Zeitschrift, Oct. 2, 1930, pages 1401-1402.

Describes a slide rule manufactured by John Davis & Sons, Derby (England) which converts a complex quantity of the form $a + jb$ into the form $Re^{j\phi}$ and vice versa by using the relations $R = a \sec\phi$, $b = a \tan\phi$. The slide rule can be used for angles between 0.1° and 90° with equal accuracy provided that the ratio b:a is not smaller than 0.001. A few examples illustrates the calculation.—H. A.

Constant Chord Gaging. W. A. J. Chapman. American Machinist, May 8, 1930, Pages 753-754.

Describes and illustrates a new practice which is much better than any present method of chordal measurement. Contains detailed formulas for the calculations.—R. H. P.

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SPECIAL

Automatic Pointation Apparatus for Telescopes (Automatischer Pointierapparat fuer Fernrohre). G. Alter, Zeitschrift fuer Instrumentenkunde, Nov. 1929, pages 553-556.

The author describes an apparatus recently patented in Czhecho-Slovakia which automatically adjusts the photographic telescope by means of reflections into a photo-cell the induced current of which is increased as to starting a relays which re-adjusts the pointation.—E. F.

Measuring Apparatus "Robur" for Cutting-Pressure and Braking Effect (Das Schnittdruck- und Bremsgerat "Robur"). A. Erienbach. Messtechnik, May 1930, pages 124-128.

After a discussion of what is taking place when a material is machined by cutting or chipping a simple instrument is developed permitting to measure the principal resistances occurring in turning, milling and drilling. The indications of the instrument are either recorded on a drum as function of the angle or transmitted to a time-measuring instrument. It is shown that the instrument based on the principle of a torsion balance can also be used in a simple manner for the determination of energy which may be of great importance considering rational and efficient utilisation of machinery. —Ha.

The Geiger Tube Election Counter. L. Curtiss. Bureau of Standards, Journal of Research, July 1930, pages 115-123.

Experiments are described which show that the sensitive surface of the Geiger tube counter is not on the wire electrode, but on the inner surface of the tube. This result explains the previously observed result that the operation of the counter is only slightly affected by the condition of the surface of the wire electrode. An explanation of the operation of the counter is offered which takes account of this additional information.

Methods of Measuring Strains Between Glazes and Ceramic Bodies. H. G. Schurecht & G. R. Pole. Bureau of Standards, Journal of Research, July 1930, pages 97-103.

A new test was developed for comparing the strains existing between different glazes or other ceramic finishes and the bodies to which they are applied. By its use these strains may be so adjusted that the finishes will be in sufficient compression to prevent crazing from subsequent expansion of the body without causing initial shivering. The new test is particularly valuable because the measurements are made on combinations of glaze and body prepared and treated almost exactly like those intended for regular use and because of the simplicity and cheapness of the apparatus required. A modification of the test provides a comparison of the moisture expansions of different bodies.

A Discussion of Hiding Power and Its Measurement. G. F. A. Stutz, Jr. & G. S. Haslem. Preprint 95, American Society for Testing Materials, June 23-27, 1930, 7 pages.

This discussion is based on results obtained by several new developments in the measurement of hiding power. An effort is made to point out the value of the several tests now in use and the interpretation that is to be put on them. The relationships existing between hiding power and brightness, and film thickness and brightness are developed. The subject is presented in light of the findings of Subcommittee VIII on Methods of Analysis of Paint Materials of the Society's Committee D-1 on Preservative Coatings for Structural Materials, and uses the tentative definition adopted by them as a working basis.

Testing Equipment for Refractory Materials. L. Litinsky. Ceramic Age, June 1930, pages 363-366.

First of a series of articles dealing with the testing of refractories as carried out in Germany. Translated from Feuerfest.

A New Electric Depth-Indicator for Mine-Hoists (Ein neuer elektrischer Tiefenanzeiger fuer Forderanlagen). Siemens Zeitschrift, Vol. 10, page 542. Elektrotechnische. Zeitschrift, Oct. 2, 1930, page 1405.

In order to obtain an exact indication of the position of the cage in the shaft Siemens-Halske utilize the air pressure before the moving cage to act on diaphragm-contacts distributed along the shaft. The arrangement is described in detail.—H. A.

Measurement of Corrosion with the "Corrosimeter" of Dr. Toedt. (Die Messung der Korrosion mit dem Korrosimeter nach Dr. Toedt). G. Gollnow, Zeitschrift fuer Feinmechanik und Praezision, Aug. 31, 1930, pages 2-4.

The instrument is based on the fact that by placing the sample and a nobler metal (f. i. platinum) together in a water solution and connecting them through a galvanometer, the current then flowing gives a direct measure for the amount of corrosion going on under the prevailing condition. As usually the corrosion is expressed by the loss of weight in g-per day and in surface the instrument is calibrated directly in loss of weight in g. The very simple arrangement is described in detail.—H. A.

Remote Control Over Iron Wire. A. F. Gettelman (General Electric Co.) Electrical World, Vol. 96, July 12, 1930, page 117.

The remote control circuit requires only a single iron telegraph wire for applications where the power line can be used for a return circuit and, in addition, 2 inexpensive contactors. The contactors require but a fraction of an ampere for operation and can be used in series in an a. c. circuit, on account of the light magnetic frame used in their construction. If remote indication is desired a 2-pole form of contactor is used at the push-button station. The circuit plan is illustrated.—W. H. B.

Rules for the Practical Testing of the Corrosion Resistance of Steels. (Richtlinien fuer die praktische Pruefung von Staehlen auf ihren Korrosionswiderstand). E. H. Schulz. Stahl und Eisen, Sept. 4, 1930, pages 1266-1269.

Report 164 of the Material Committee of the Verein deutscher Eisenhuettenleute. Rules are proposed in order to standardize corrosion tests. The behavior of steels toward corrosion can be determined exactly only by tests requiring a long time. Rules are given for taking the samples to be tested, preparation and marking of samples and the observation of the corrosion process. Rules are also outlined for short time corrosion tests, generally applied in laboratory tests, which, in many cases, pass reliable judgment.—G. N.

The Determination of the Anti-Knock Value of Motor Fuels. M. Taubert. Chemical Engineering & Mining Review, July 5, 1930, pages 368-370.

It is generally recognized: (1) that straight chain paraffin hydrocarbons possess the greatest tendency to knock; (2) the unsaturated as a whole possess less tendency to knock than the paraffins (3) the naphthenes as a whole possess less tendency to knock than the paraffins; 4) the aromatic hydrocarbons possess a still less tendency to knock than (3) and are considered as knock suppressors. Chemical analyses are shown to be inaccurate in judging the knock of anti-knock value of a fuel. Engine testing is the only satisfactory means. Five methods of engine test are outlined. The use of pure normal heptane and iso-octane (2, 4, 4 trimethylpentane) should provide a standard for rating of fuels as regards the "anti-knock" value. This value would be expressed in terms of mixtures of these hydrocarbons.

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A. J. A. PETERSON, INSTRUMENTS, Vo. 4, No. 2, February 1931, pages 51-53, 2 figs.

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